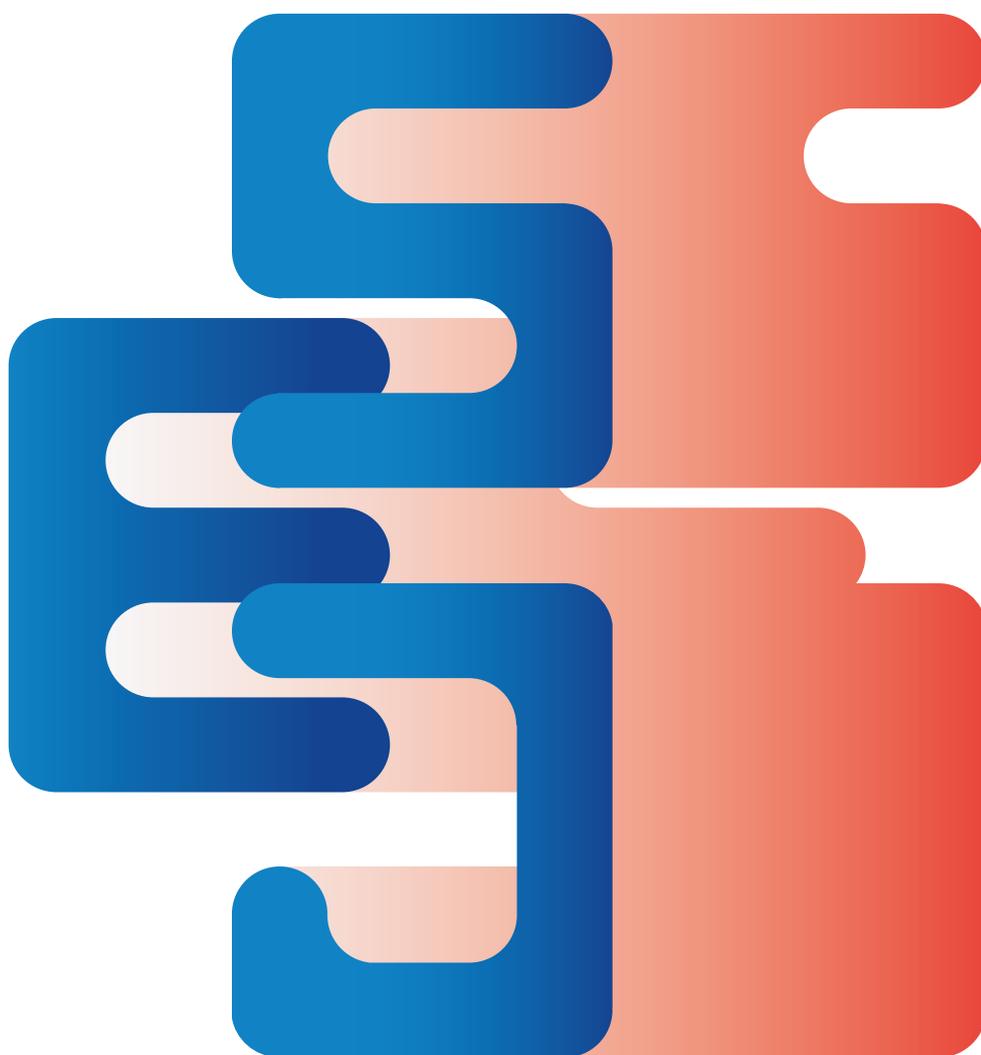




# Setting Europe on course for a human digital transition



New evidence from Cedefop's second  
European skills and jobs survey



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The **European Centre for the Development of Vocational Training** (Cedefop) is the European Union's reference centre for vocational education and training, skills and qualifications. We provide information, research, analyses and evidence on vocational education and training, skills and qualifications for policy-making in the EU Member States. Cedefop was originally established in 1975 by Council Regulation (EEC) No 337/75. This decision was repealed in 2019 by Regulation (EU) 2019/128 establishing Cedefop as a Union Agency with a renewed mandate.

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# Foreword

Digitalisation has been a powerful driver in labour markets and society for decades. The first reference to the ‘information society’ concept in an EU policy document dates to 1979. The Delors White Paper in 1993 advocated developing a pan-European information structure to boost economic growth and to create new markets and jobs. At the start of the ICT revolution, the paper already acknowledged that digital skills are at the core of employability.

Thirty years later, we see all around us that digitalisation has transformed the way we live, work and learn. With digitalisation accelerating, the future of work is here and no longer a buzz phrase referring to the nature of employment, jobs and skills in a distant future. Positioned strategically alongside the green transition, a just digital transformation has become a key policy concern.

Jobless future scenarios propagated by technological alarmists at the time technology accelerated will not materialise. This report clearly shows that the digital transition is first and foremost a skills transition, not an uncontrollable job destructing megatrend. Some jobs will be lost and some tasks will be taken over by robots or other technology but, simultaneously, new jobs and tasks will emerge.

EU digitalisation, (vocational) education and training and skills policies rightly emphasise how crucial it is that Europe’s citizens have the possibilities and means to develop, upgrade or update their digital skills. To be fully effective, such policies need to be complemented with innovative approaches to promoting skills utilisation in work, by reshaping or redesigning jobs, maximising their learning potential, empowering workers or via new approaches to work organisation.

This report uses Cedefop’s second European skills and jobs survey (ESJS2) to provide new empirical insight into how digitalisation impacts different types of jobs and groups of adult workers with different skills levels. Going beyond what is common in many other surveys of workers, it details the impact of the pandemic, maps the use of different types of digital technology and their implications for jobs and workers, and reflects on changing tasks and skills needs. These novel and innovative aspects of the survey help make the case for public and private action that blends skills formation, job enrichment and task upgrading.

With this report, Cedefop aims to provide state-of-the-art evidence in support of the EU’s digital and skills agendas and their ambitious targets. The 2023 European Year of Skills is an excellent opportunity to engage in further discussion and debate on how to support business and citizens to take ownership in using technology to transition to a more prosperous and fair society.

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The Cedefop project *Second European skills and jobs survey: data collection and impact of digitalisation and technological change on skill mismatch of EU workers* (contract: FWC 2019-FWC06/AO/DSL/KPOUL-MSERA/ESJS/001/19), on which the analysis in this report is based, was managed by Cedefop experts Konstantinos Pouliakas and Marco Serafini.

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# Executive summary

About a decade ago, most debates on the future of work emphasised the negative consequences of robots and machine algorithms. Bold claims about digital technologies massively displacing people and the research-based finding that close to a half of all jobs in developed countries could be automatable, made headlines. Acknowledging that digital technology typically automates part of an occupation's job tasks and not entire jobs or occupations, later analyses contributed to a shift in thinking. In the minds of experts and policy-makers, the doom and gloom outlook of techno-alarmism made way for a more balanced perspective towards technology and its labour market impacts. Many workers still see things differently. Four in 10 EU+ (EU-27 and Norway and Iceland) workers – and 46% of those in high digital intensity jobs – think that there is some chance they may lose their job in the next 12 months. About half of them think the job-displacing features of digital technology are to blame.

Evidence-based insight into digitalisation and its impacts on European jobs and workers is essential for policy-makers. But mapping the digital transition and digging deeper into what trends really mean for skills, jobs and workers is easier said than done. Fully grasping how digital technology (re)shapes the world of work requires analyses that blend labour demand trends (such as changing digital skill demands) and labour supply aspects (such as digital skills development and use in the workplace). Between and within-job dynamics, job complexity, routinisation and job quality, skill mismatches, and perceived advantages and risks of interacting with digital tools among workers and their employers are other factors that must be considered.

With the second European skills and jobs survey (ESJS2) Cedefop aims at strengthening the evidence base underpinning EU VET, skills, digital and related policies. Surveying over 46 000 adult workers in 29 European countries, it takes a comparative perspective, collects up-to-date and

scientifically sound information, and fills important knowledge gaps.

## Headline findings

ESJS2 analysis sheds new light on digitalisation in the context of the COVID-19 pandemic, the changing nature of skill demand and work, skill mismatch, digital skills and other continuing skill development. The new findings reflect the innovative measurement approaches the ESJS2 employed. These capture the changed dynamics in how labour markets and workers react and adapt to digitalisation and help provide better insight into the interlinkages between jobs, tasks, skills and learning.

The following ESJS2 headline findings – all referring to the EU+ adult workforce – summarise the state-of-the-art analysis presented in this report. They are structured thematically and integrate key messages for policy-makers.

## The pandemic and digitalisation

- (a) In 2020-21, almost half of adult workers saw new digital technology introduced at their workplace and 35% of them had to learn how to use it. The fact that such workers were more likely to be in workplaces that grew in staff size, suggests companies embracing the 'digitalisation push' managed to navigate the coronavirus crisis better and thrived.
- (b) Compared to before the COVID-19 pandemic, four in 10 adult workers more often use digital technology to perform some of their job tasks and three in 10 worked more time away from their employer's premises.
- (c) Exposure to new technology and upskilling for it varies with occupation skill level, education, gender and age, demonstrating inequality in access to technology and technology-enabled learning.

- (d) Online education and training boomed during the COVID-19 crisis. More than six in 10 adult workers participating in education or training during 2020-21 did so online at least once.
- (e) Many workers not using computer devices lack awareness of new realities in the world of work or are oblivious to automation risks. Eight in 10 believe that new digital technology would result in a small improvement in the speed or quality of their work and only one in four are concerned that technology can or will (partly) do their tasks.
- (f) For most other European workers affected by digitalisation, digital transformation implies task content redesign rather than job displacement. Although there will be job and task destruction by machines or robots in some labour market segments, digitalisation primarily leads to massive skilling needs.

### Jobs, tasks, and skill needs

- (a) 52% of all EU+ jobs have low skill demands; in 31% skill demands are moderate and in 17% they are high. Over half of all jobs in Europe are relatively repetitive and standardised. But regularly following fixed procedures or instructions or highly repetitive work tasks do not necessarily mean low autonomy, problem-solving and learning. Routine work and task discretion coexist in many jobs.
- (b) While almost all adult workers use some digital technology, six in 10 carry out relatively basic or low-intensive digital tasks at work, and one in eight none. Although robots and 3D printers feature prominently in the popular Industry 4.0 discourse, only about 8-9% of adult workers work with or operate such technology.
- (c) Despite modest (digital) skill demands in EU+ jobs, there is still learning potential: six in 10 adults need to develop further their knowledge and skills to do their job better, and more than half need to improve their digital skills.
- (d) There is significant scope to digitalise further many jobs in Europe. For many workers digitalisation can go hand-in-hand with job quality provided they have the means to up- or reskill: digital jobs are less likely to be routine jobs, typically have higher autonomy and more skill development opportunities, and yield higher job satisfaction.
- (e) It is important to avoid that further digitalisation, particularly in manual occupations, results in more routine jobs where workers feel less secure. Introducing new computerised machines, such as robots, can have this effect. Workers in non-routine, analytical jobs are less affected by such negative impacts of digital technology.

### Skills mismatches

- (a) The education level of four in 10 workers is not matched to that required by their job: 28% is overqualified and 12% is underqualified. Non-users of digital devices and workers less exposed to learning new digital technologies are more likely to be overqualified. The overqualified perceive less scope for further developing their skills to improve job performance compared to matched and underqualified adult workers.
- (b) With almost two thirds (65%) of workers in jobs that require their field of study or a related one, horizontal mismatch appears to be lower than vertical (qualification) mismatch.
- (c) Seven in every 10 skilled occupation workers report significant dynamic skill gaps, signalling substantial unmet learning needs. This contrasts sharply with the over half of (often low-educated or low-skilled) adults in elementary jobs or jobs with no or little digital intensity who reported limited or no skill development needs. Mirroring limited incentives and lacking stimulus for learning in their jobs, many of them do not realise the importance of investing in their skills or have little learning ambition.
- (d) European adult workers using no or only basic digital technology and the lower educated tend to have fundamental digital skill gaps that limit employability, productivity and career development opportunities. The potential for digital skill development is prominent for high-skilled professionals and those in high digital intensity jobs, but also common for those who have been employed for a long time with the same employer.
- (e) One in two adult workers acknowledge they need to upgrade their social skills, 40% needs

- to develop their technical skills further, and 29% acknowledges a numeracy skills deficit.
- (f) Sustaining and possibly amplifying such marked skill gaps, only 45% of adult workers can use the knowledge and skills they have in their main job to a great extent. A large majority of workers in a manual or elementary occupation job does not fully use their skills potential at work. This points towards significant potential to improve skills utilisation at work.

### Digital skills training

- (a) While 45% of adult workers acknowledge they need new knowledge and skills to work with new digital technology, only one in four took part in digital skills training in 2020-21.
- (b) Digital skills training is more prevalent among high-educated adults in high-skilled occupations and among those employed in larger-sized firms. Adults who need digital skills training most (those not using digital technology at work or insulated from digitalisation) often do not do it.
- (c) Much digital skills training in Europe is not very substantial. Half of those who had to upskill digitally for work required a week at most to master the most frequently used technology.
- (d) Expanding basic or mid-level digital skills training would benefit many workers. One in every five adult workers and 31% of those not using computer devices, stands to gain from training in navigating the web. 30-40% of the workforce can be further trained in fundamental word processing and use of spreadsheets.
- (e) Workers that do learn typically blend learning types to master new computer software or digital machines introduced in their workplace: learning from colleagues, via a course, workshop, seminar or on the job, and self-learning are widespread.

### The bottom line

Alongside the green transformation, achieving a just digital transition is at the heart of European Union policy ambitions. This transition is not what will happen in a ‘future of work’; it may be already all around us. Continuing the integration of new

digital technologies into the world of work, more advanced technological advances are already on the horizon. The European Union’s skills and digital agendas and their ambitious targets point towards what the bloc wants to achieve. The evidence in this report suggests that, for many European workers at the lower end of the labour market, digital skills transformation is not yet a reality. Workers in automatable jobs often do not realise technology threatens them. Many are trapped in non-complex jobs that underutilise their potential and offer few (digital and other) skills development opportunities.

Policy-makers and researchers have expressed hopes that the digital transition can contribute to reshaping work in a human-centric way, where people seamlessly collaborate with technology, rather than being replaced by it. This will require a focus on digital technology as a means to achieve societal goals beyond efficiency and the urgently needed upskilling revolution. Placing worker well-being and quality jobs at the core of technological transformation will be key to setting Europe on course to a more human digital transition and machine age.

# Reimagining the future of work

## 1.1. Shocks and uncertainty reshaping the world of work

Crisis, disruption, and transformation have had lasting impacts on EU and global economies and societies in the past decade. At a time when the lingering and unequal effects of the 2008 global financial crisis were still visible, and south European countries in particular were still recovering, the COVID-19 pandemic brought the entire world to a standstill. The situation of severe shocks and disruptions challenging societies which are still learning to live with the pandemic, has been termed ‘permacrisis’. Disruption in global supply chains, war, turmoil in global energy markets, stagflation, increasingly visible climate change and social unrest are having enormous impacts. Increased uncertainty challenges governments and citizens, and amplifies concerns about joblessness, skill mismatches and job-displacing technological automation.

The global COVID-19 health and social crisis and unprecedented lockdown measures had a particularly strong impact on work and work organisation in EU enterprises. Most EU companies saw changes in core business activities and almost all had to adapt business operations, which had implications for how they manage staff (Van Loo et al., 2021). Along with fostering what now appears to be a structural shift towards digital and remote working and learning, demand for digital skills in European economies increased. This applies to digital skills at all levels: basic (e.g. virtual communication), specialised (e.g. e-commerce, digital marketing and sales) and advanced (e.g. big data analytics, business ICT systems, programming) (1).

The COVID-19 pandemic accelerated the long-standing trend towards greater digitalisation of work in EU economies. The debate about the likely ‘future of work’ before the current crises

already focused on rapid technological advancements made possible by new, Industry 4.0 digital technologies. Greater awareness of the expanding frontier of technological possibilities fuelled such discussions and challenged entrenched assumptions on what technology could and could not do.

Technological change has influenced the nature and organisation of work throughout human history. While most net effects are positive there are also non-negligible costs for disadvantaged population groups (Frey, 2019). Recent technological innovation, which is often considered part of the ‘4th industrial revolution’ (Schwab, 2016), is viewed as a trend greatly expanding the potential for job automation. The proliferation of new digital technologies (including virtual reality, robotic process automation, artificial intelligence (AI), 3D printing and the internet of things (IoT)), are transforming the economy and the way people work and learn in unprecedented ways. Cutting-edge AI and advanced robotics go far beyond traditional algorithmic or rule-based approaches to computer programming. They make a wide range of cognitively challenging tasks that were long considered to be impossible to automate, susceptible to be replaced by machines (Brynjolfsson et al., 2018). While, ultimately, such ‘digital disruption’ is likely to impact every economic sector and transform corporate practices, including talent management strategies, the extent to which digitalisation is pursued varies widely, depending on priorities set in economies and organisations (Bughin, 2017).

Early debates on the future of work were mostly about the consequences of machine-driven algorithms and robotic technologies for employment. The discourse and discussions were heavily influenced by the so-called job polarisation or routine-biased technological change (RBTC) hypothesis (Autor et al., 2003; Acemoglu and Autor, 2011). Bold claims about digital technologies massively displacing people and the finding that close to a half of all jobs in developed countries

(1) See [Coronavirus and the European job market: how the pandemic is reshaping skills demand](#). Cedefop news headline, 18.12.2020.

could be automatable (Frey and Osborne, 2017; Rifkin, 2014; Susskind, 2020; WEF, 2016), made headlines. Analysis of the US labour market showed that using robots drives job losses and has negative wage impacts, particularly for people in middle-skill, routine or manual jobs (Acemoglu and Restrepo, 2020).

Later analyses disproved such pessimistic assessments and acknowledged that digital technology typically automates part of an occupation's job tasks, not entire jobs or occupations (Arntz et al., 2017; Nedelkoska and Quintini, 2018; Poulidakas, 2018). Labour market analyses on Europe and other developed economies also did not find evidence of widespread net job destruction (Dauth et al., 2017; Klenert et al., 2022). Some labour displacement may occur in technology-intensive production, but inter-sectoral job growth and re-allocation of job-tasks among incumbent workers tend to offset the negative employment impact of automation.

The impact of robotisation on jobs and wages varies between firms of different sizes and skill intensity. Employment increases faster in firms adopting robots (Koch et al., 2019; Acemoglu et al., 2020). Age, skill and seniority jointly determine how workers are affected when their employer invests in capital-intensive, task-automating equipment (Bessen et al., 2020).

## 1.2. Fear of robots and machines

Digital innovation is widely acknowledged as a game changer for economies, companies and workers (Brynjolfsson and McAfee, 2014). Views on its likely future impact continue to oscillate (Brown et al., 2018). Some convey fear of the rise and rule of robots (Ford, 2015, 2021); others paint a more optimistic picture of human resilience and job-task transformation (Acemoglu and Restrepo, 2019; Autor, 2015). Distancing themselves firmly from doom and gloom portrayals of a jobless future, some analysts expect the amount of work to increase substantially in the future (Willcocks, 2020; OECD, 2021a).

Such conflicting rhetoric shapes popular perceptions of the value and possible negative

repercussions of introducing or mainstreaming digital technology. Overemphasising or even exaggerating the negative effects fuels feelings of personal insecurity and possibly contributes to shifting political orientations towards the extremes. Gnambs and Appel (2019) noted that attitudes in Europe towards autonomous robotic systems assisting workers are becoming more negative and attribute this trend to media attention and public discussion about robots 'stealing people's jobs'. In a world with 'fake news' and algorithms deciding which information reaches people, beliefs become self-reinforcing ('filter bubbles'). Regardless of whether beliefs are based on unbiased and sound evidence, how people feel about technology is likely to determine the extent to which they are willing to embrace it. Feelings will also affect their readiness to prepare for the future of work, including their CVET preferences and participation (Busemeyer et al., 2022).

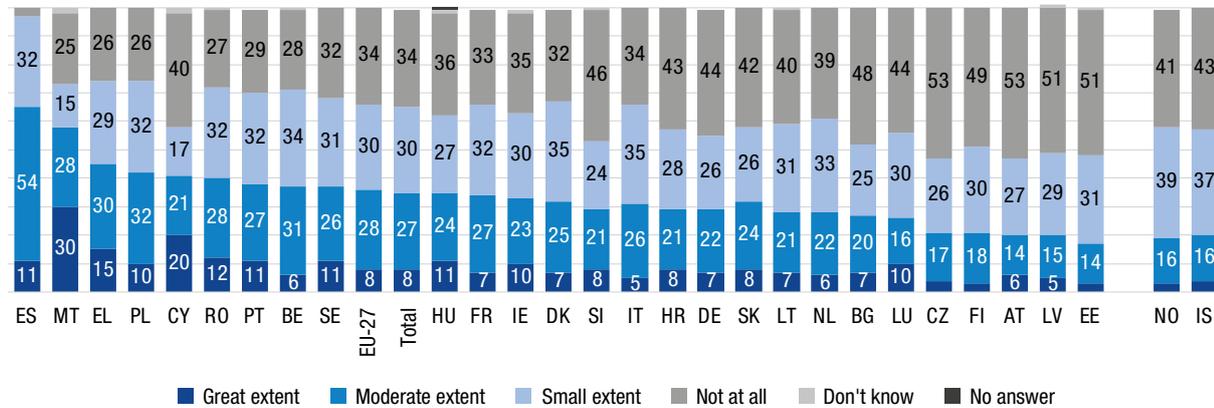
Cedefop's second European skills and jobs survey (ESJS2) shows that about four in 10 (38%) workers in the 27 EU Member States, Norway and Iceland (hereafter referred to as EU+) think that there is a chance they may lose their job in the next 12 months. Around 35% express great or moderate concern that new digital or computer technology will soon take over their main job or part of it. 30% characterise their concerns as small (Figure 1). Workers in southern Europe (Spain, Malta, Greece, Cyprus, Portugal) are more concerned about being displaced by technology than their counterparts in other EU Member States (Austria, Norway, Iceland, Latvia, Czechia) and countries considered technological leaders (Estonia, Finland).

## 1.3. Embracing the skills revolution

Recent research challenges technological alarmism by acknowledging the complex underlying dynamics and inter-relationships shaping the equilibrium impact of new digital technologies on labour market outcomes. Whether a digital technology has a labour-substituting or -complementing effect depends on a multitude of factors. Alongside capabilities of a technology and its

Figure 1. Impact of new digital technologies on potential job displacement

**F\_DISPLJOB:** TO WHAT EXTENT DO YOU THINK NEW DIGITAL OR COMPUTER TECHNOLOGIES IN YOUR COMPANY OR ORGANISATION CAN OR WILL DO PART OR ALL OF YOUR MAIN JOB?



Source: Cedefop second European skills and jobs survey, 2021.

cost relative to the price of labour/skill, compatibility with existing work methods and practices, organisational strategies, managerial aptitude, ease of adoption and assimilation, worker skill gaps, and social dialogue are part of the equation (Souto-Otero et al., 2021; Cedefop, 2020a; Wajcman, 2006).

Compensating market mechanisms (e.g. positive inter-sectoral consumer demand effects and productivity-tied wage setting), an innovation-friendly environment, and training policies may also counteract the job-destroying impact of technological innovation (Goos, 2018). The impact of digital technology on productivity, jobs and wage growth will also depend on the dynamic reallocation of job tasks between machines and humans, with the rebalancing resulting from displacement and ‘reinstatement’ of labour into a broader range of (new) tasks (Acemoglu and Restrepo, 2018).

Challenging the partial perspective of much of the early technological unemployment/job polarisation literature in its understanding of the impact of technological change leads to important and policy-relevant insight. Scholars point out that within-occupation changes in job content (Freeman et al., 2020) and the skills up- or downgrading associated with technological change (McGuinness et al., 2021; Deming and Noray, 2020) are the lion’s share of labour market dynamics.

Many EU+ adult workers understand that digitalisation drives up- and reskilling needs. Almost

half (45%) of the workers the ESJS2 surveyed reported that new digital technologies will require knowledge and skills they currently do not have (Figure 2). Such ‘skill gap’ perceptions tend to be higher in countries where automation fears are widespread (e.g. Spain, Malta, Poland, Greece). In only a few European countries (Norway, Netherlands, Lithuania) many workers acknowledge skilling needs despite low automation concerns.

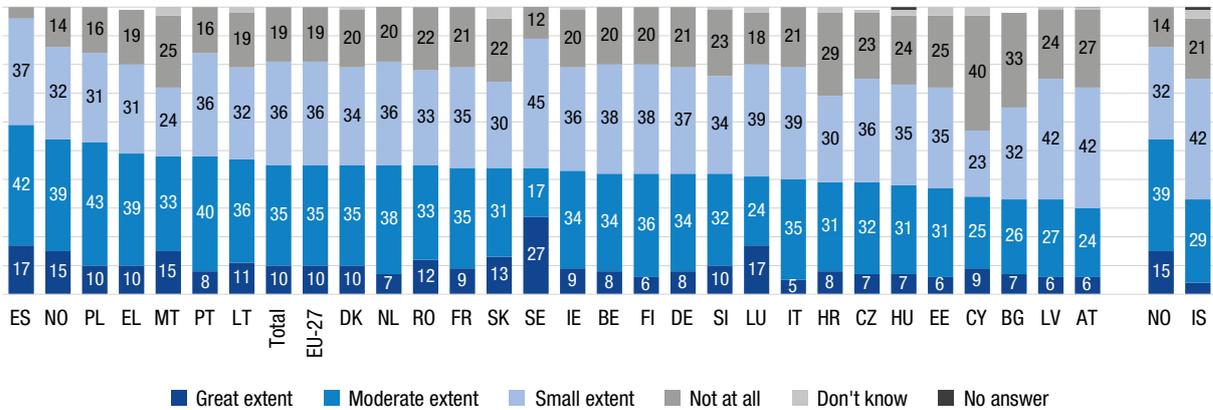
### 1.4. Cedefop’s second European skills and jobs survey

The narrow focus on automation in the early debate on the future of work has overshadowed discussions on other impacts of digitalisation on work. Central questions around how digitalisation is affecting what workers do and whether and how education and skills development can enable individuals to benefit from, rather than be threatened by, technological change, have been somewhat sidelined. Aspects such as strengthening workers’ adaptability and building resilience to deal with unexpected social shocks have only recently come into focus.

Much of the empirical literature informing debates on automation has relied on national or firm-level data. International surveys of workers that make it possible to devise harmonised and comparative measures of digitalisation, skill needs,

Figure 2. Impact of new digital technology on skill needs

**F. DISPLSKIL:** TO WHAT EXTENT DO YOU THINK NEW DIGITAL OR COMPUTER TECHNOLOGIES IN YOUR COMPANY OR ORGANISATION NEED OR WILL NEED NEW KNOWLEDGE AND SKILLS YOU CURRENTLY DO NOT HAVE?



Source: Cedefop second European skills and jobs survey, 2021.

and skill mismatches have been lacking. To fill the gaps in understanding the extent to which workers from different European countries are being impacted by digitalisation, and to inform EU digital and skills policies, Cedefop carried out the second European skills and jobs survey (ESJS2) in mid-2021 (Box 1).

The ESJS2 explores how technology has come to be used in workplaces in Europe and looks at the impact of digital technologies and technological change on work, skill needs and skill mismatches (²). The survey collected nationally representative data from 46 213 adults aged 25-64 in wage and salary employment (i.e. paid employees, excluding those in self-employment and family workers). It was fielded between May and July 2021 in 29 European countries (EU-27 plus Iceland and Norway, henceforth EU+).

The ESJS2 concept and questionnaire was developed in 2018-20 by Cedefop experts with the support of a group of international experts and a leading international survey company (Annex 1). The questionnaire underwent rigorous and high-quality pre-testing and translation, meeting the highest standards of international survey design and implementation. Fieldwork was carried by dual mode (telephone and online) design. It

combined random probabilistic phone interviews (at least 500 per country) with sample top-ups drawn from reliable online panels. Sample quotas were enforced to the online samples to ensure the representativeness of the employee workforce in each country, with reference to their gender, age, region, education, occupation, and sector of employment. Appropriate weighting ensures that the ESJS2 data is balanced and in line with the distribution of key population variables in each country. The weighting method gives particular emphasis to adjusting for the inherently higher digital abilities of online panel respondents. Annex 2 describes the adopted ESJS2 sampling methodology in more detail.

The ESJS2 collects complete information on the socio-demographic (age, gender, education, urbanity, region) and job (e.g. sector, occupation, years of employer tenure, firm size, type of contract, work hours, earnings, job satisfaction) profile of EU+ adult workers. It maps the task structure of EU+ jobs and uses it to proxy job-skill requirements in labour markets. The focus is on literacy (reading, writing), numeracy, physical, interpersonal and problem-solving tasks, along with digital activities carried out at work and the incidence and impact of technological change for work. ESJS2

(²) Digitalisation tends to have wider consequences on labour markets, extending beyond its automation and job quality impacts. Much literature also considers its contribution to lowering coordination costs and fostering the rise of self-employment and online platform work (Cedefop, 2020b, 2021d; Pouliakas and Ranieri, 2022). As it focuses on a sample of paid adult employees, the ESJS2 cannot provide insight into this aspect of digitalisation. By excluding unemployed or inactive workers and focusing on labour market ‘survivors’, it also cannot offer robust evidence on the wider, system-level dynamics underlying job destruction or polarisation in EU labour markets.

**Box 1. In brief: Cedefop's second European Skills and Jobs Survey (ESJS2)**

The ESJS2 is the second wave of a Cedefop periodic survey collecting information on the job-skill requirements, digitalisation, skill mismatches and workplace learning of representative samples of European adult workers. It builds on the first wave carried out in 2014. The ESJS2 aims to inform the policy debate on the impact of digitalisation on the future of work and skills, also in the context of the COVID-19 pandemic.

Fielded in spring-summer 2021, ESJS2 collected information about 46 213 adult workers in the EU-27 Member States plus Norway and Iceland (EU+). Cedefop has joined forces with the European Training Foundation (ETF). By end 2023, the ESJS2 will have been carried out in more than 35 countries.

The survey aims to address the following questions:

- What is the impact of the COVID-19 pandemic on employment, work and skills?
- To what extent did workers have to learn new digital technologies (computer software or computerised machinery) in their main job during the COVID-19 period?
- To what extent did workers have to adopt new digital (remote) ways of working and learning?
- What is the impact of new digital technologies on job-skill requirements?
- At what level of digital complexity do workers need to upskill or reskill?
- Does digitalisation in jobs foster job routinisation or work autonomy and higher job quality?
- To what extent are adult workers affected by (digital) skills mismatches?
- How effective is workers' participation in continuous vocational training to mitigate digital and other skill gaps?

ESJS2 aspires to become a key tool for evidence-based policy-making in VET. Its design incorporates the growth, sustainability and resilience ambitions of the [EU Skills Agenda](#) and [European Digital Strategy](#) and acknowledges the importance of digital skills in VET put forward in the [2020 Council Recommendation on VET](#) and the [Osnabrück Declaration](#). ESJS2 also provides the evidence to support the aim of making [Europe fit for the digital age](#) and to realise the ambitions of the [European digital education action plan](#), the [European pillar of social rights action plan](#) and the [2030 digital compass](#). It complements the [Digital economy and society index \(DESI\)](#), the [European digital competence framework \(DigComp\)](#) and other EU data and information on digitalisation and its impacts. ESJS2 data and analysis are central to Cedefop's [skills and labour market work](#), which aims to strengthen EU skills intelligence and support the twin – digital and green – transitions. More information on [the European skills and jobs survey \(ESJS\)](#) is available on Cedefop's web portal.

Source: Cedefop.

also collects information characterising the nature of work and its organisation (e.g. routine, autonomous, standardised, learning-intensive). The extent to which skill mismatches affect digital and overall productivity at work and efforts to mitigate them via education and training is also measured. The variety and richness of variables measured in the survey makes it possible to estimate partial correlations (but not necessarily causal ones) between key economic and social variables using multivariate regression techniques.

## 1.5. Themes covered in the report

The key ambition of the ESJS2 is to contribute to evidence-based EU policy-making. Crossing traditional policy boundaries, Cedefop uses the ESJS2 results to showcase what it takes to shape a more human digital transition and machine age. Blending economic and social objectives starts with acknowledging that the labour market impact of different types of digital technology (computer software or programs, computerised machines and equipment) can vary by location and pop-

ulation segment: there is no single but a variety of ‘futures of work’ likely to emerge. Therefore, alongside the core findings, this report also gives insight into the redistributive effects of digitalisation at work (Autor, 2015). It does so by comparing results across countries and by using socio-demographic variables, such as occupation, sector of employment and education level, to structure their presentation.

By presenting ESJS2 data and findings, this report contributes to five themes that are central in recent and current policy debates on the future of work and skills in the EU and its Member States.

Chapter 2 presents new evidence on the impact of the COVID-19 pandemic on jobs in the EU+ and on how workers adapted to new, digital ways of working and learning.

Chapter 3 analyses the nature and complexity of digital skill demand in European labour markets. It also provides a harmonised and internationally comparable measure of the extent of digitalisation/technological change that took place in the first year of the COVID-19 pandemic.

Chapter 4 links digitalisation to the changing nature of work in EU+ job markets and reflects on how the take-up of digital technologies drives skill demand, changes job content and affects job quality.

Chapter 5 looks at educational and skills mismatches in the context of rapid technological change, focusing on the prevalence of digital skill gaps (Cedefop, 2015a, 2018a; McGuinness et al., 2018). Digitalisation is expected to affect skills mismatch, as it places a premium on certain skills (e.g. analytical skills) and high-skilled work while reducing demand for other skills.

Chapter 6 explores how widespread is learning around new technologies and provides detailed insight into the upskilling/reskilling undertaken by EU+ workers, in the context of a marked decline in time learning on the job due to the COVID-19 crisis (OECD, 2021b).

Chapter 7 concludes by reflecting on the policy implications of the main findings presented in the report for the EU digital, skills and VET agenda, considering also the ambitious digital skills targets to be attained by 2030. The chapter interprets the results in the context of the 2020 [European Skills Agenda](#), the [Osnabruck Declaration](#) and the [Council Recommendation on VET](#), which place digital skills at the heart of the EU’s ambition to achieve effective twin (digital and green) transitions. It also aims to stimulate further reflection on developing digital competences and skills, as set out in the European Commission’s [Digital Decade Policy Programme](#) and [Digital Skills Agenda](#).

#### EU digital skill targets to be reached by 2030

**80%**

of adults must be equipped with at least basic digital skills



**20 million**

ICT specialists must be employed, gender-balanced



**75%** of EU companies should be using cloud computing/AI/big data technologies



More than **90%** of EU SMEs should reach at least a basic level of digital intensity



Source: [European Commission](#).

# COVID-19 and the digital transition

## 2.1. The labour market impact of the pandemic

In the wake of the COVID-19 crisis, previously unimaginable confinement measures were put in place around the world to contain the spread of the virus. The EU and the governments of its Member States adopted extraordinary labour market measures to support businesses, lives and livelihoods. These aimed at mitigating large-scale sectoral job reallocations and at preventing the surge of long-term unemployment that would otherwise have occurred. ESJS2 evidence on the impact of the coronavirus crisis confirms that European and national COVID-19 support measures have been relatively effective in stemming rising joblessness in EU+ labour markets.

Only about 6% of workers surveyed in the ESJS2 in 2021 reported having lost their previous job because of the pandemic. Underemployment, however, soared (Figure 3). For close to one in three EU+ workers, mostly younger and lower-educated, the health emergency meant reduced (20%) or no working hours (10%), even though they kept their jobs (e.g. through a fur-

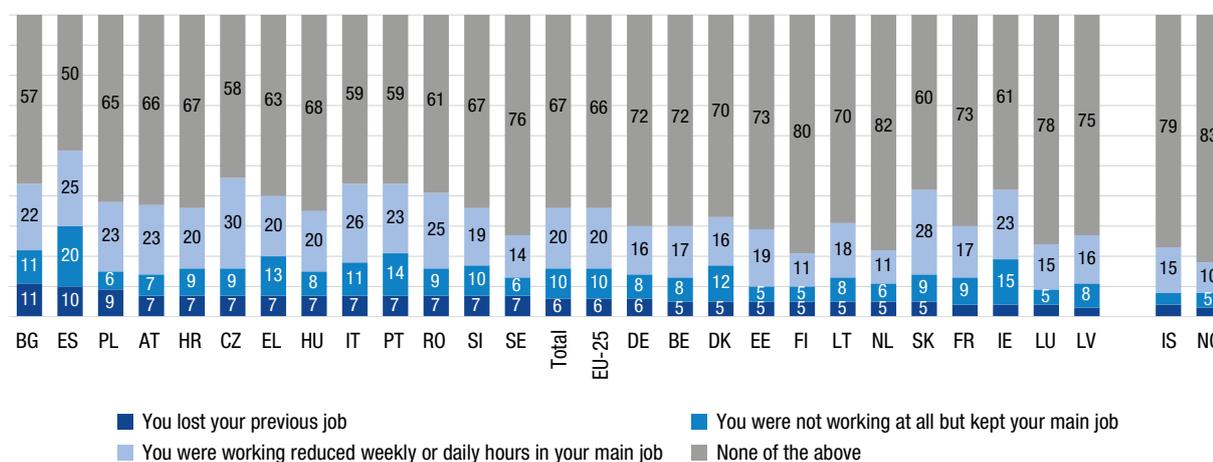
lough or other short-time work scheme). While two in three (67%) EU+ workers did not face a direct change in employment status, the inactive European population increased (Eurofound, 2020).

In spite of the macro-economic resilience of European labour markets during the health crisis, COVID-19 hit several economic sectors (e.g. hospitality, transport, arts and leisure) particularly hard. People in jobs where face-to-face social interaction is at the core of daily work, and digital or remote work is difficult to achieve or out of reach, were most negatively affected (Pouliakas and Branka, 2020). While some scholars expected aggregate labour market imbalances to return to the pre-pandemic ‘normal’ once COVID-19 restrictions were fully lifted (Pizzinelli and Shibata, 2022), it is becoming increasingly clear that global economic uncertainty in the aftermath of the pandemic is likely to aggravate skill mismatch tensions at micro level.

Recent evidence suggests that the difficulties in sourcing talent and skills EU employers have been facing for several years were temporarily muted during the pandemic, but they have quickly returned to pre-pandemic levels, affecting about

Figure 3. Labour market consequences of the COVID-19 pandemic

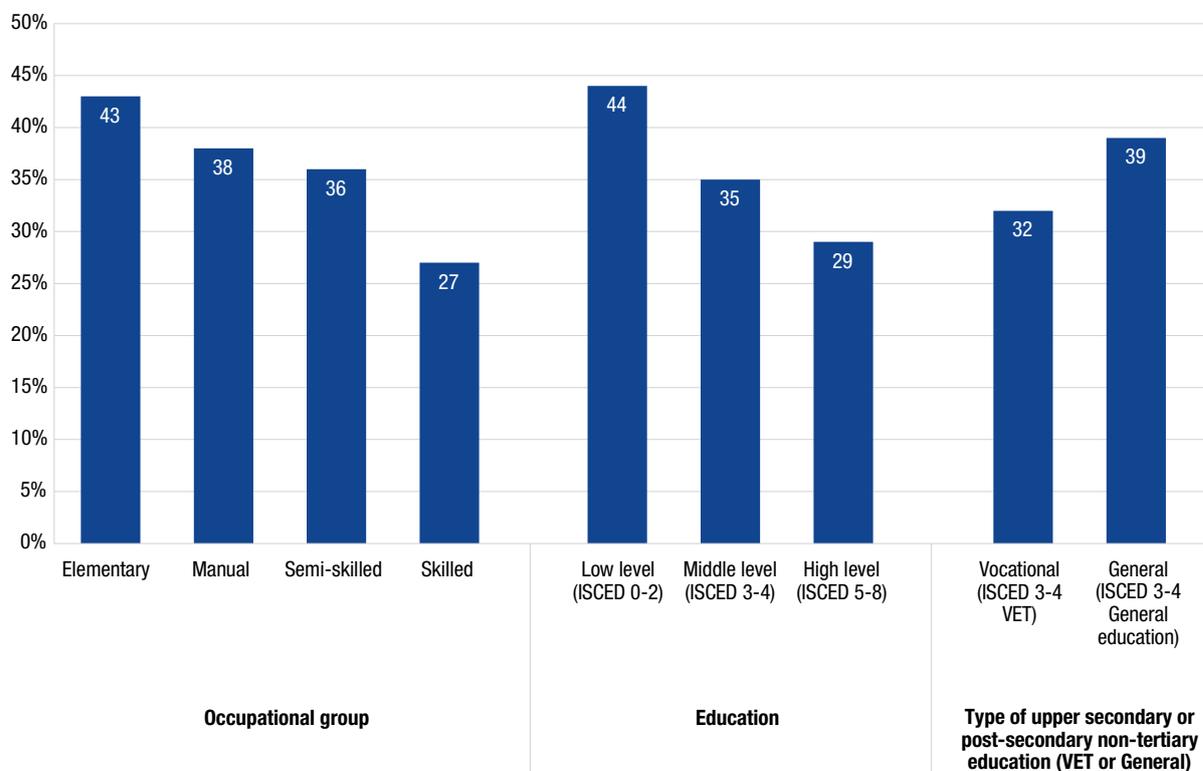
G\_COVID1: DID YOU EXPERIENCE ANY OF THE FOLLOWING AS A RESULT OF THE COVID-19 (OR CORONAVIRUS) PANDEMIC?



NB: The COVID-19 questions were only asked in the online ESJS2 sample; no data are available for Cyprus and Malta; weighted data. Source: Cedefop second European skills and jobs survey, 2021.

Figure 4. Labour market effects of COVID-19 pandemic by socioeconomic characteristics

**G\_COVID1:** DID YOU EXPERIENCE ANY OF THE FOLLOWING AS A RESULT OF THE COVID-19 (OR CORONAVIRUS) PANDEMIC? LOST YOUR PREVIOUS JOB, NOT WORKING BUT KEPT MAIN JOB, OR REDUCED WEEKLY/DAILY HOURS



NB: The COVID-19 questions were only asked in the online ESJS2 sample; no data are available for Cyprus and Malta; weighted data.  
Source: Cedefop second European skills and jobs survey, 2021.

three in four EU firms. It is alarming that labour and skill shortages coincide with a collapse of corporate training investments and (informal) training participation in the post-COVID-19 period (Poulikas and Wruuck, 2022; Van Loo et al., 2021).

The pandemic affected workers at the lower end and the middle of the skills spectrum more severely than workers in skilled occupations (Figure 4). Nearly half of workers in elementary occupations and those with a low qualification were confronted with job loss, work interruption, reduced working hours, or a combination of these negative pandemic impacts. This was only the case for around 30% of skilled and higher-educated workers. Medium-educated workers with vocational qualifications were less likely to be affected than those with general secondary education. It is likely that a vocational qualification shielded workers from the COVID-19 shock, because they are less present in the sectors most heavily affected and more present in 'essential' jobs. Non-users of

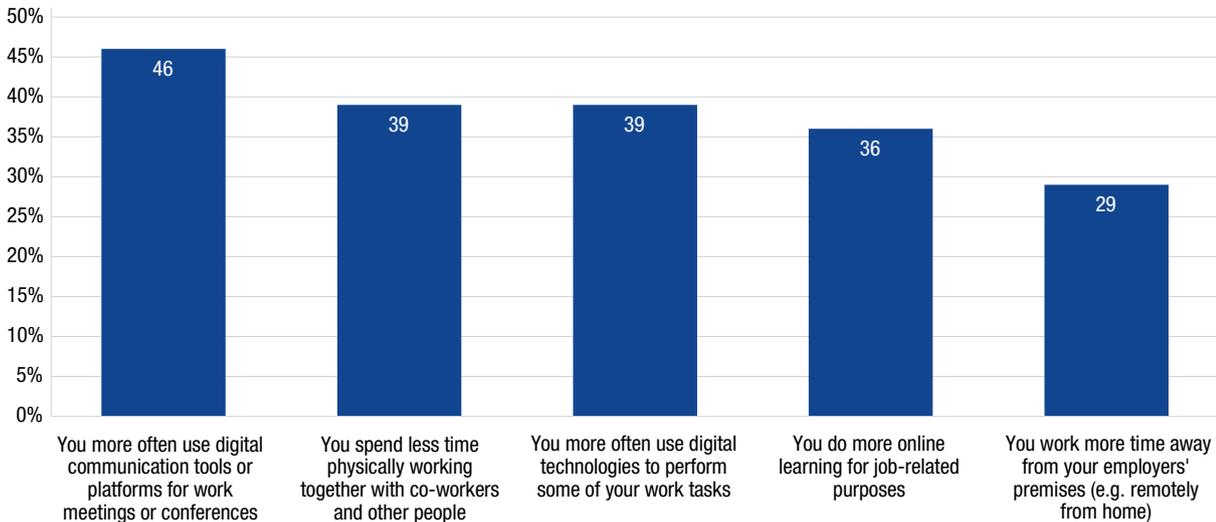
digital technologies at work were highly susceptible to the negative consequences of the pandemic (see also Chapter 3).

## 2.2. COVID-19 accelerating digitalisation at work

Most workers were able to continue working during COVID-19, but work life was often not 'business as usual'. Major changes were introduced that impacted how people work and how they upskill. The ESJS2 uncovers the unprecedented impact social distancing practices had on the social fabric of workplaces, pointing towards the urgency of digital innovation in customer and human resource management. Compared to the pre-pandemic era, 39% of EU+ workers spent less time physically working together or with other people; 29% worked more remotely (notably, from home) (Figure 5).

Figure 5. COVID-19 pandemic and digital work and learning

**G\_COVID2:** COMPARED WITH THE SITUATION BEFORE THE COVID-19 PANDEMIC, DO YOU NOW EXPERIENCE ANY OF THE FOLLOWING SITUATIONS IN YOUR MAIN JOB?



NB: The COVID-19 questions were only asked in the online ESJS2 sample; no data are available for Cyprus and Malta; weighted data.  
Source: Cedefop second European skills and jobs survey, 2021.

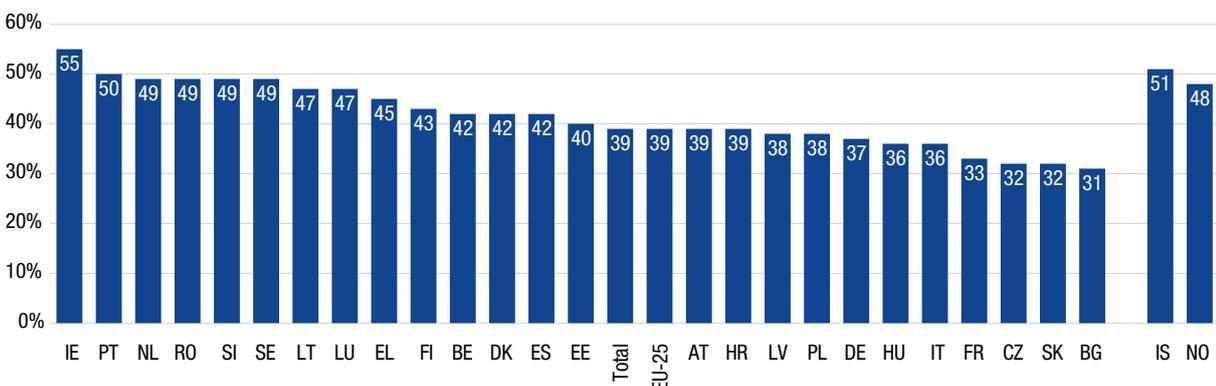
COVID-19 accelerated the adoption of digital technology, with about four in 10 European workers (39%) reporting they use it more often in their work tasks. Approximately five in 10 EU+ workers had to use digital communication tools or platforms more often for work meetings or conferences (46%). Such trends make digital technologies a more integral part of work in EU labour markets (Vargo et al., 2021).

In Ireland and the Nordic countries the coronavirus had a widespread impact on digitalisation in jobs (Figure 6). This is also the case in some

southern (Portugal, Greece) and eastern (Romania, Slovenia, Latvia) European countries. Pandemic-driven job digitalisation is less pronounced in Bulgaria, Slovakia, Czechia and France, with less than a third of workers using digital technology more often. In 13 of the 29 European countries surveyed, more than half of employed adults use digital communication technology for work meetings or conferences more often than before the pandemic. With over 60%, Sweden, Finland, the Netherlands, Ireland, Iceland, and Norway lead the ranking. In Poland (39%), Slovakia (39%), Czechia

Figure 6. Increasing use of digital technologies in jobs during COVID-19 pandemic, EU+

**G\_COVID2.4:** COMPARED WITH THE SITUATION BEFORE THE COVID-19 PANDEMIC, DO YOU NOW EXPERIENCE ANY OF THE FOLLOWING SITUATIONS IN YOUR MAIN JOB? YOU MORE OFTEN USE DIGITAL TECHNOLOGIES TO PERFORM SOME OF YOUR WORK TASKS

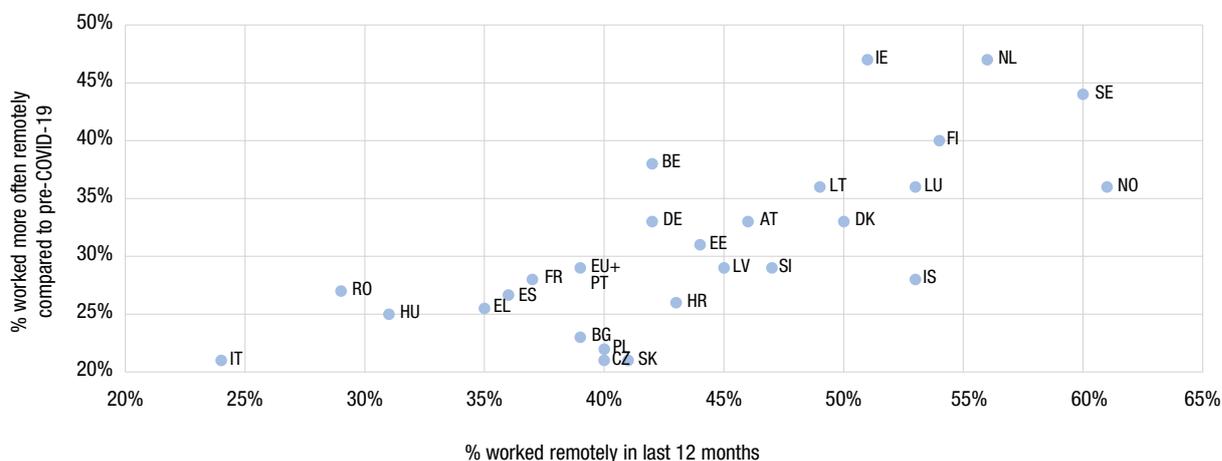


NB: The COVID-19 questions were only asked in the online ESJS2 sample; no data are available for Cyprus and Malta; weighted data  
Source: Cedefop second European skills and jobs survey, 2021.

Figure 7. Remote work during COVID-19 pandemic, EU+

**HORIZONTAL AXIS: B ICTWK:** IN THE LAST 12 MONTHS, DID YOU DO ANY WORK AS PART OF YOUR MAIN JOB FROM A LOCATION OTHER THAN YOUR EMPLOYER'S PREMISES?

**VERTICAL AXIS: G\_COVID2:** COMPARED WITH THE SITUATION BEFORE THE COVID-19 PANDEMIC, DO YOU NOW EXPERIENCE ANY OF THE FOLLOWING SITUATIONS IN YOUR MAIN JOB? YOU WORK MORE TIME AWAY FROM YOUR EMPLOYER'S PREMISES (E.G. REMOTELY FROM HOME).



NB: The COVID-19 question on the vertical axis was only asked in the online ESJS2 sample; no data are available for Cyprus and Malta; weighted data.  
Source: *Cedefop second European skills and jobs survey, 2021*.

(36%) and Bulgaria (34%), the trend towards more digital communication is less pronounced.

There are stark differences in the uptake of digital technology between occupational groups. Half (51%) of workers in skilled occupations increased their use of digital technologies because of COVID-19. The corresponding shares for workers in semi-skilled occupations (33%), manual (24%), and elementary (20%) occupations are much lower.

### 2.3. Remote working and learning

One of the most pervasive effects of COVID-19 is that it reconfigured the 'place of work' for many workers, reducing physical presence and contacts with colleagues in buildings. In mid-2021, 39% of EU+ workers reported to have worked outside of their employers' premises at least sometimes in the 12 months prior to the survey. This finding is consistent with those found in other studies (Eurofound, 2021; Sostero et al., 2020).

Although most virus-related restrictions have been lifted, interest in the place of work remains high among policy-makers. Recent concerns about a 'great resignation' – many people leav-

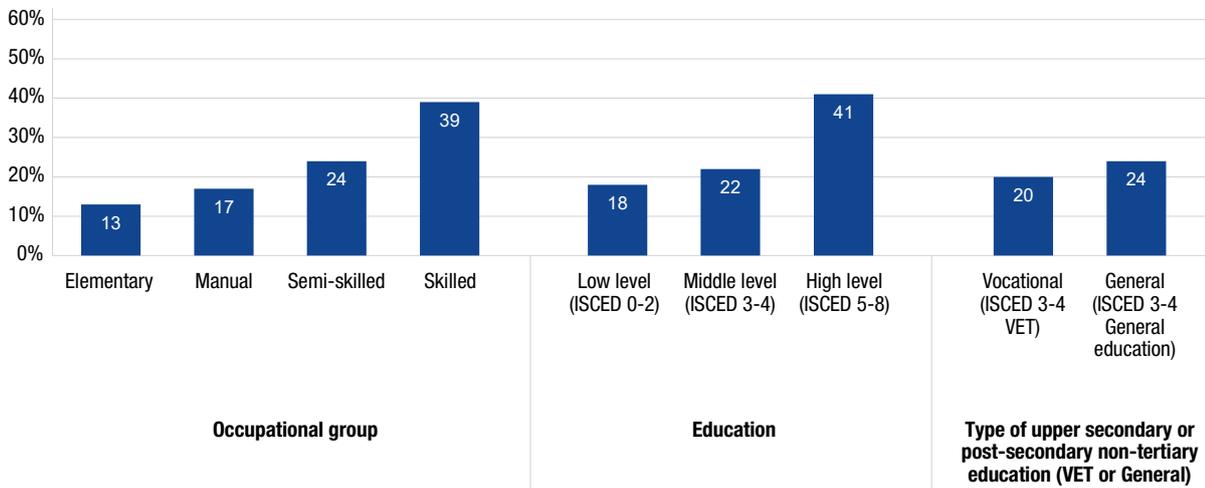
ing their jobs or thinking about leaving their jobs in the post-pandemic period (Sull et al., 2022) – have been linked to some organisations reversing flexible work arrangements (Tessema et al., 2022). The growing preference for at least some work away from employer premises between 2020-21 (Eurofound, 2021) suggests that telework and working from home arrangements are likely 'to stick' (Barrero et al., 2021).

Significant inequalities in remote working and learning during the COVID-19 pandemic indicate the importance of policy aimed at bridging digital divides in the EU workforce. The prevalence of remote work in national labour markets reflects the composition of tasks in employment (Sostero et al., 2020) and the work organisation paradigms in European countries (Fana et al., 2020). Nordic countries and Ireland appear to have embraced new digital ways of working to a greater extent than southern and eastern Europe countries (Figure 7).

Higher-educated workers (or in high-skilled occupations) are more than twice as likely to have increased remote work during the pandemic than lower-educated workers (Figure 8): 18% of lower-educated workers worked more remotely during the first COVID-19 year, while among those with tertiary level education, 41% expanded remote

Figure 8. Trends in remote work by socioeconomic characteristics

**G\_COVID2.1:** COMPARED WITH THE SITUATION BEFORE THE COVID-19 PANDEMIC, DO YOU NOW EXPERIENCE ANY OF THE FOLLOWING SITUATIONS IN YOUR MAIN JOB? YOU WORK MORE TIME AWAY FROM YOUR EMPLOYERS PREMISES (E.G. REMOTELY FROM HOME)



NB: The COVID-19 questions were only asked in the online ESJS2 sample; no data are available for Cyprus and Malta; weighted data.  
 Source: *Cedefop second European skills and jobs survey*, 2021.

work. The share of those who increased working away from their employers’ premises in skilled occupations was three times that of workers in elementary occupations. Working from home was most prevalent in ICT (63% of workers), financial (54%) and professional services (46%). Logically, it is much lower in accommodation and food services (12% of workers), utilities (19%) and ‘essential’ human health and social work services (17%). As the jobs of medium-educated workers with a vocational qualification more often require physical presence, fewer of them could work away from employer premises compared to their general education counterparts.

75% of the workers who worked remotely used a computing device (e.g. desktop pc, laptop/notebook, tablet) all or most of the time. In all countries more than six in 10 workers who worked away from their employers’ premises could do so thanks to a computing device. The use of such devices for remote work is highest in Ireland (90% of workers), the Netherlands (88%), and Luxembourg (86%).

Almost nine in 10 workers in skilled jobs or with higher education levels worked away from employers’ premises using a computing device, typically a laptop or desktop computer. This contrasts sharply with the minority of manual and elementary workers or those with low levels of education using such a device when working remotely. These

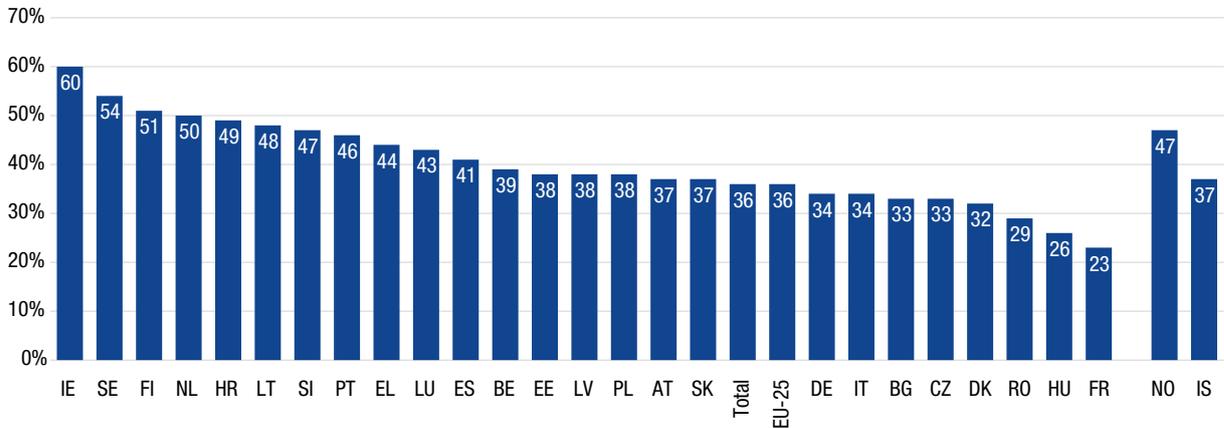
results suggest a large gap in digital skills usage between workers in skilled and less skilled occupations and in the capacity to continue working when away from employers’ premises.

Unable to attend education or training courses, conferences/workshops or meetings in person, or to benefit from interaction with fellow workers in their job, 36% used the internet for job-related learning. The OECD (2021b) has noted time spent on non-formal and informal learning at work during the coronavirus period has substantially decreased. ESJS2 evidence suggests that countries differ considerably when it comes to using technologies for job-related learning to compensate for such losses (Figure 9). On average in European countries, around a third of workers reported an increase in the use of online learning for work. In Ireland (60%), Sweden (54%) and Finland (51%) such increases were much more widespread. Fewer than one in three workers reported increases in online work-related learning in France (23%), Hungary (26%), Romania (29%) and Denmark (32%).

Opportunities for job-related online learning during the pandemic were very unevenly distributed in the workforce. 47% of workers in skilled occupations and 31% of those in semi-skilled occupations reported increases in online learning. For manual (23%) and elementary (18%) occupations, the shares are much smaller. The impact of

Figure 9. Trends in online learning for job-related purposes during COVID-19 pandemic, EU+

**G COVID2.5:** COMPARED WITH THE SITUATION BEFORE THE COVID-19 PANDEMIC, DO YOU NOW EXPERIENCE ANY OF THE FOLLOWING SITUATIONS IN YOUR MAIN JOB? YOU DO MORE ONLINE LEARNING FOR JOB-RELATED PURPOSES



NB: The COVID-19 questions were only asked in the online ESJS2 sample; no data are available for Cyprus and Malta; weighted data.  
 Source: Cedefop second European skills and jobs survey, 2021.

educational inequalities is also evident, as 49% of the higher educated experienced increases in job-related online learning, compared to 28% of those educated at medium level and 23% of those with a lower-level qualification.

The analysis in this chapter shows that European countries, businesses and individuals with greater digital readiness to adapt to remote work-

places and social distancing practices appear to have better weathered the storm. Differences in the use of technology explain why the impact of COVID-19 on individuals at work was much more negative for those that were not in skilled jobs that can be supported by digital technology and performed remotely during lockdown.

**Key ESJS2 statistics on digital work in the EU+ during COVID-19**

Compared to before the COVID-19 pandemic, **39%** of EU+ workers more often use digital technology to perform some of their job tasks

**29%** worked more time away from their employer's premises, compared to before the COVID-19 pandemic

Compared to before the COVID-19 pandemic, **36%** of EU+ workers more often do online learning for job-related purposes

**75%** worked remotely using a computer device all or almost all the time

**39%** of EU+ adult workers worked away from their employer's premises (mainly from home) during the (mid)2020-21 period

**72%** are regular teleworkers (work remotely at least once a week) 28% are occasional teleworkers

Source: Cedefop second European skills and jobs survey, 2021.

# Digitalisation and digital skills

## 3.1. Measuring digital technologies

Technology research focuses on its employment-transforming impact and the factors driving corporate adoption decisions (Cascio and Monteleone, 2016). Research investigating the type and extent of digital technology used at work is limited. Studies on digital technology at work typically focus on the use of ‘computers’ and do not reflect the variety of digital technologies used in workplaces, particularly in low and middle-skilled occupations (Dhondt et al., 2002). As a result, the wider use of digital technologies at work has been underestimated. Analysis on the impact of technology can also be considered biased in the sense that the results ‘disproportionally reflect the effects for workers who perform more cognitive tasks’ (Salvatori et al., 2018).

The impact of technology on workplaces cannot be properly assessed without going beyond the narrow technology perspective much previous labour market research has taken: using (personal) computers at work. Balsmeier and Woerter (2019) note that machine-based, digital technology such as robots, the internet of things and 3D printing are central drivers of the 4th industrial revolution (ILO and UNESCO, 2020). Survey instruments

need to reflect such trends and measure the use of different digital technologies in workplaces, including computerised machinery and equipment (Salvatori et al., 2018). Having this in mind, Cedefop designed the ESJS2 to capture a broad range of digital technologies at work in Europe, including computer devices that rely on software and programmes and computerised machines typically used in factories, construction sites, warehouses, repair shops and for transportation or other services (Box 2).

The results this chapter presents show that the use of digital technology is widespread in EU workplaces and that different types of digital technology have penetrated EU workplaces to varying degrees. In 2021, almost nine out of 10 employed adults used computer devices to do their work. This suggests a marked increase in technology use compared to the beginning of the century when around 50% of workers used computers at work (Andries et al., 2002), but also compared to the pre-pandemic period (Bisello and Fernandez-Macias, 2019; Centeno et al., 2022). Around four out of 10 workers use computerised machines, a type of technology often not considered in empirical studies mapping the labour market impact of ICT technology.

### Box 2. Measuring digitalisation in the EU+ labour market

To measure the extent to which EU+ adult workers regularly use digital or computer technologies in their main job, the ESJS2 asked respondents the following questions. These were extensively tested to ensure that they are as factual as possible and avoid any cultural, linguistic, and other biases related to respondents’ socioeconomic background:

#### Computer devices and related software:

*Which of the following computing devices do you use to do your main job? Please select all that apply.*

1. Desktop computer
2. Laptop / notebook computer
3. Tablet computer
4. Smartphone
5. None of them
88. Don't know
99. No answer

**Computer activities:***[Asked to all users of computer devices]**Did you use any of the computing devices from the previous question to do the following activities as part of your main job in the last month?**[Asked to all non-users of computer devices]**Do you know how to use a computing device for doing the following activities?*

- Use the internet for browsing, sending emails or using social media for your work
- Write or edit text, for instance using Word or similar software
- Prepare presentations of your work, for instance using PowerPoint or similar software
- Use spreadsheets, for instance using Excel or similar software
- [If use of spreadsheets] And use the more advanced functions of spreadsheets, for instance macros or complex formulas
- Work with any specialised, sector or occupation-specific software, for instance for accounting, legal analysis, inventory control, web design, graphic design, customer relationship management, etc.
- Manage and merge databases, for instance using Access, Oracle or similar software and related query techniques (e.g. SQL)
- Write programmes or code using a computer language, for instance C++, Python, Java, Visual Basic etc
- [If write programmes] Write programmes using artificial intelligence methods, for instance machine-learning or deep-learning algorithms
- Develop or maintain IT systems, hardware or software

**Computerised machine technologies:***As part of your main job, did you work with or operate any of the following computerised machinery in the last month?*

- Digital handheld devices, for instance monitors or scanners used for stock control and processing orders
- Computer numerically controlled (CNC) machine tools, for instance lathes or milling machines
- Robots
- Programmable logic operators (PLCs)
- 3D printers
- Other specialised, sector or occupation-specific computerised machinery (e.g. lasers, CT scan, smart whiteboards, etc.)

Note: respondents were instructed that computerised machines do not include personal computer devices or standard printers used in an office or at home.

Source: Cedefop second European skills and jobs survey, 2021.

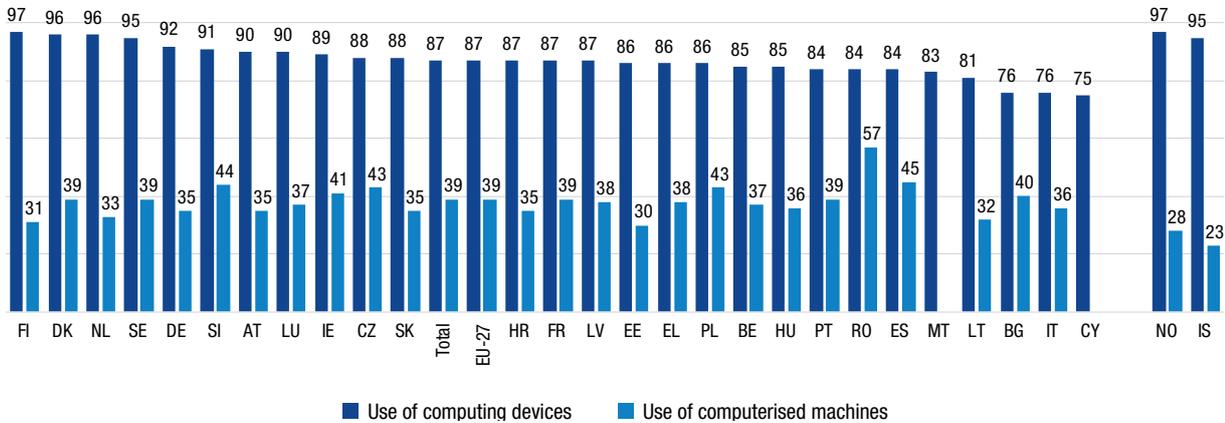
### 3.2. Use of digital technology at work

The use of computing devices at work is widespread in all European countries (Figure 10). On average, close to nine in 10 adult workers (87%) use such a device to do their work; the share

ranges from 97% of adult workers in Finland and Norway to 75% in Cyprus. While computerised machines at work are also common (39% of adult workers), this varies more across countries. More than four in 10 EU+ workers use them in central and eastern Europe countries (e.g. Romania, Poland, Czechia, Slovenia, Bulgaria) and in Spain;

Figure 10. Use of digital technologies in EU+ labour markets

D\_PCD/D\_CM: USE of computing devices/Use of computerised machinery at work

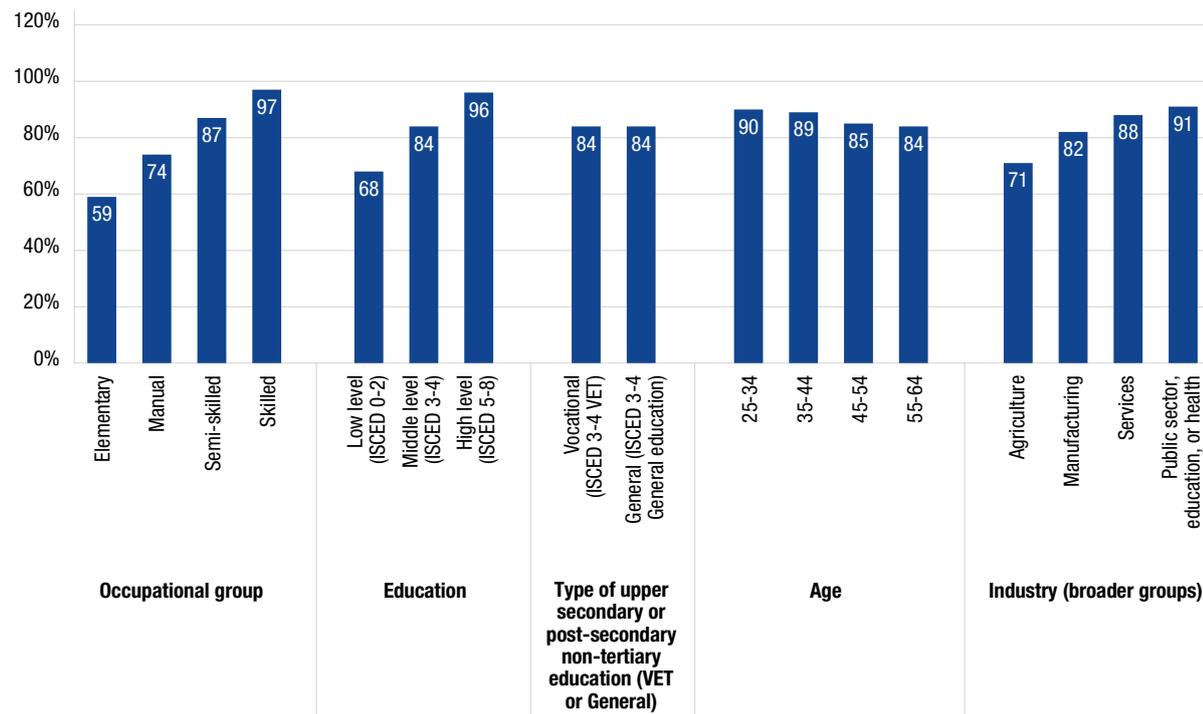


NB: Only online ESJS2 survey participants were asked the question about the use of computerised machines; no data are available for Cyprus and Malta; weighted data.

Source: Cedefop second European skills and jobs survey, 2021.

Figure 11. Use of computer devices at work by socioeconomic characteristics

D\_PCD: USE OF COMPUTING DEVICES AT WORK



Source: Cedefop second European skills and jobs survey, 2021.

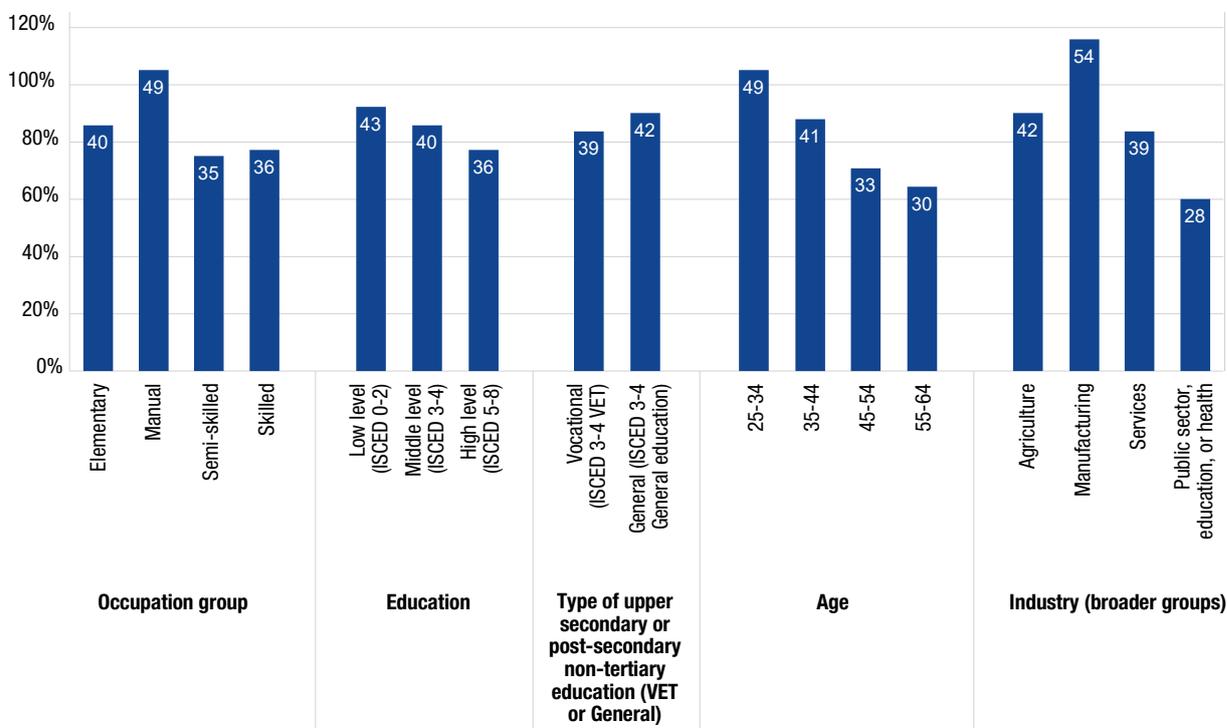
only 28% do so in Norway and 23% in Iceland.

Workers in more skilled occupations and with higher levels of education use computer devices at work more often (Figure 11). While nearly all (97%) workers in skilled occupations use them to do their work, 74% of manual workers and only 59% in elementary jobs do so. Those with higher education

(ISCED 5-8) nearly always use computer devices for work (96%); 68% of lower-educated workers (ISCED 0-2) do so. Adults employed in services (88%), or the public sector (91%) use computer devices more often than in industry (82%) or agriculture (71%). Males and younger-aged workers are more frequent users of computing devices. At

Figure 12. Use of computerised machines at work by socio-demographic characteristics

D\_CM: USE OF COMPUTERISED MACHINES AT WORK



NB: Only online ESJS2 survey participants were asked the question about the use of computerised machines; no data are available for Cyprus and Malta; weighted data.

Source: Cedefop second European skills and jobs survey, 2021.

medium education level, programme orientation (VET versus general education graduates) has no distinct influence on computer use.

Manual workers use computerised machines more often than workers in other occupations: 49% compared to 40% of those in elementary occupations, 36% of skilled workers and 35% of semi-skilled workers (Figure 12). Sectoral differences in using digital machines are more pronounced than those found for computer devices. About half of all workers in manufacturing (54%), wholesale and retail trade (53%) and the transport sector (46%) use such machines, compared to 39% in services and only 28% in the public sector. Lower-educated workers use computerised machines more often than those with higher education (43% compared to 36%) and age also plays an important role. While one in two (49%) younger workers (aged 25-34) use or operate computerised machines at work, less than one in three (30%) workers aged 55-64 do so.

### 3.3. Digital skill demand

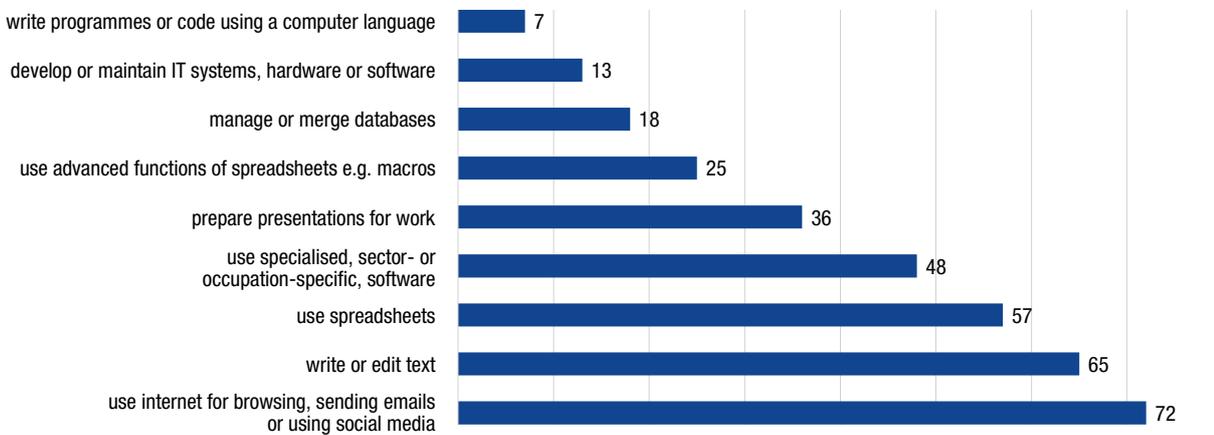
#### 3.3.1. Level of digital skills required at work

Academic experts and policy-makers acknowledge the increasing importance of digital technology at work for labour productivity and agree that digital skills are employability drivers (Non et al., 2021). There appears to be less consensus about the level of digital skills required in EU labour markets. Most representative surveys among workers point towards having at least basic digital skills as a requirement in the vast majority of jobs (e.g. European Commission's DESI index, OECD's PIAAC survey, Eurofound's EWCS, and the UK Skills and Employment survey). Cedefop's first European skills and jobs survey (Cedefop, 2015a, 2018a) showed that over eight in 10 EU jobs require at least basic level digital competence.

Empirical work suggests that the typical level of digital skills required in European workplaces is moderate at most. Most jobs (typically 50-60%)

Figure 13. Digital activities in main job, EU+

**D\_PC\*:** DID YOU USE ANY OF THE COMPUTING DEVICES MENTIONED EARLIER TO DO THE FOLLOWING ACTIVITY AS PART OF YOUR MAIN JOB IN THE LAST MONTH?



Source: Cedefop second European skills and jobs survey, 2021.

require medium-level digital skills (e.g. word processing or use of spreadsheets) and less than two in 10 need advanced digital skills (e.g. computer programming or software development) (Centeno et al., 2022). Such figures suggest low investment in digital technology in EU economies and firms and appear inconsistent with narratives reporting rapid proliferation of advanced digital technologies (such as robotics, blockchain, AI) and the staff shortages resulting from it (Benbya et al., 2020). It is not always made clear that such claims are often based on the analysis of non-representative, biased (big) data (Sostero et al., 2021; Sostero and Tolan, 2022). They largely reflect what is happening in (groups of) high-skilled professions and industries, so they cannot be interpreted as reflecting the lion's share of digital skill demand in advanced economies.

The above contradiction shows the added value of robust, harmonised and comparative data that measure the use of digital technologies at work, and the digital skill level required to use or operate them. The ESJS2 shows (Figure 13):

- (a) 60–70% of EU+ workers use digital tools at work that require basic or moderate level digital skills (e.g. web browsing, emailing, word processing, use of spreadsheets);
- (b) close to a half use specialised job-specific software;
- (c) between one in five (18%) and a quarter (25%) engage in relatively advanced database management activities;

- (d) 13% require advanced digital proficiency (e.g. to develop and maintain ICTs);

- (e) 7% engage in computer programming for work.

Less than a decade ago, Barley (2015) noted that ‘the internet is rapidly becoming as infrastructural as electricity’ at work. The ESJS2 confirms that almost three quarters of workers (72%) use the internet in their job, making it the most common digital work activity. Highly educated workers are almost twice as likely to use the web at work (88%) as the low-educated (45%).

The education level impact on internet use is also visible in occupations: 87% of workers in skilled occupations use the web as part of their main job, compared to 49% of manual workers and only 38% of those in elementary occupations. Hardly any difference is found between workers in different age groups. This demonstrates the importance of digging deeper to map and explain differences in internet use and skills within the older adult population, rather than considering it a group that does not use such technologies (Hargittai and Dobransky, 2017).

Internet use at work ranges from 88% in Iceland to 60% in Bulgaria. In southern and eastern Europe, internet-enabled computer technologies at work are less widespread than in countries in the west and north.

While some countries are significantly above (e.g. Luxembourg) or below (e.g. Italy) the European average in the use of digital tools at work, deviations indicate comparative specialisation

(Table 1). For example, Ireland cannot be considered a leader with respect to the use of more standard applications but takes a leading position when it comes to programming. Portugal also performs comparatively well in more advanced

computer applications.

The type of computerised machine most used in EU+ job markets is a digital handheld device (26%), followed by other, occupation- or industry-specific, specialised computerised machines

Table 1. **Use of computer applications at work by EU+ country**

	Use internet	Use Ms Word	Use Ms Powerpoint	Use Spreadsheets	Use Advanced Spreadsheets	Use specialised software	Manage databases	Use programming	Use advanced programming for AI	Develop or maintain IT systems, hardware or software
IS	88%	76%	38%	65%	17%	61%	16%	6%	1%	16%
FI	87%	75%	40%	59%	21%	56%	14%	8%	1%	19%
NL	86%	74%	49%	65%	28%	58%	17%	10%	2%	12%
SE	86%	76%	50%	66%	25%	48%	16%	10%	2%	16%
LU	85%	81%	47%	74%	33%	57%	24%	11%	3%	14%
SI	83%	74%	37%	69%	29%	52%	19%	9%	2%	16%
NO	82%	73%	41%	59%	21%	39%	9%	8%	1%	14%
DK	80%	72%	44%	59%	22%	50%	16%	7%	1%	13%
AT	78%	73%	38%	62%	26%	47%	20%	9%	2%	13%
PT	77%	70%	44%	64%	30%	52%	22%	9%	4%	14%
EE	77%	62%	28%	58%	20%	48%	14%	5%	2%	8%
HR	77%	67%	28%	55%	17%	40%	19%	5%	1%	10%
IE	76%	73%	49%	66%	33%	41%	21%	12%	5%	17%
EL	76%	67%	34%	59%	27%	40%	16%	7%	1%	18%
LV	75%	63%	25%	58%	14%	47%	16%	6%	1%	9%
MT	75%	64%	43%	61%	25%	46%	25%	8%	3%	10%
DE	74%	72%	37%	61%	27%	54%	22%	6%	1%	11%
RO	73%	64%	37%	57%	24%	43%	15%	7%	1%	12%
SK	72%	67%	30%	61%	17%	50%	9%	9%	2%	10%
TOTAL	72%	65%	36%	57%	25%	48%	18%	7%	1%	13%
BE	71%	63%	39%	58%	24%	49%	21%	9%	3%	12%
EU-27	71%	65%	36%	57%	25%	49%	18%	7%	1%	13%
CZ	70%	63%	26%	61%	22%	51%	10%	6%	1%	9%
ES	70%	64%	38%	55%	24%	46%	20%	9%	1%	14%
PL	69%	62%	31%	55%	22%	45%	16%	5%	1%	11%
FR	68%	57%	38%	53%	25%	54%	16%	9%	1%	16%
HU	67%	63%	30%	58%	27%	33%	31%	9%	0%	13%
CY	65%	54%	32%	50%	18%	31%	12%	7%	2%	10%
LT	64%	57%	33%	52%	18%	40%	18%	5%	1%	10%
IT	62%	55%	30%	49%	22%	38%	17%	5%	1%	13%
BG	60%	53%	27%	54%	19%	46%	19%	6%	1%	7%

Source: Cedefop second European skills and jobs survey, 2021.

**Box 3. Use of Industry 4.0 technologies at work**

An important ambition of the ESJS2 is to collect robust, comparative statistics that are representative of skill demand for key Industry 4.0 technologies in European labour markets. The survey focused on measuring the extent to which EU+ workers work with or operate specific types of computerised machines as part of their main job, including autonomous robots (industrial or otherwise) and 3D printers. Such digital technologies underpin additive manufacturing and are cornerstones of the digital transformation of production processes in the context of the fourth industrial revolution.

ESJS2 analysis shows that about 9% of the EU+ workforce operate 3D printers as part of their job and 8% work with robots. This shows the use of such digital equipment is concentrated in specific industries and occupational groups. The use of robots (Figure 15) is most common in the manufacturing (17%) and construction (11%) sectors, and in accommodation and food service activities (9%). In jobs in public administration and related public sector activities it is much lower (3-4% of adult workers). Manual workers are most likely to work alongside or with robots (16%), along with some of those employed in elementary jobs (11%). Robots are much less often part of the workplace for skilled (7%) or semi-skilled employees (5%).

3D printers are most used in the construction sector (13% of adult workers), in agriculture (11%) and in manufacturing (11%). They are also deployed in professional, scientific and technical services (10% of adult workers). Manual workers (e.g. 11% of craft and related trades workers and 10% of skilled agricultural occupations) quite often use 3D printers at work, but this is also the case for high-skilled managers (11%).

There are significant gender and age differences because male and younger workers are more likely to use computer-controlled machines. While lower-educated employees are on average more likely to use or operate robots, education level does not appear to significantly affect the likelihood of working with 3D printers.

Source: Cedefop second European skills and jobs survey, 2021.

(15%) (Figure 14). Despite the growing emphasis on robots and 3D printers as archetypes of the 4th industrial revolution, only about 8-9% of EU+ adult workers work with or operate such computerised machines at work (Box 3).

The geographic pattern distinguishing north and south/east European countries found for use of computing software is not visible when it comes to computerised machines. For example, the use of digital handheld devices is more common in Romania (43%), Poland (29%), Greece (28%) and Ireland (28%). Only 13% of workers in Iceland and 15% in Finland and Lithuania use them. National differences in use of computerised machines or equipment should be considered when analysing differences in digitalisation at work between European countries and regions.

Occupation and age play a relatively important role in whether or not adult workers use comput-

erised equipment as part of their job. Workers in manual occupations, for example, use digital handheld devices to a greater extent compared to those in skilled occupations (29% versus 23%, respectively). Younger workers operate digitally controlled machines more often than older ones (33% of those aged 25-34 versus 19% of 55 to 65 year-olds).

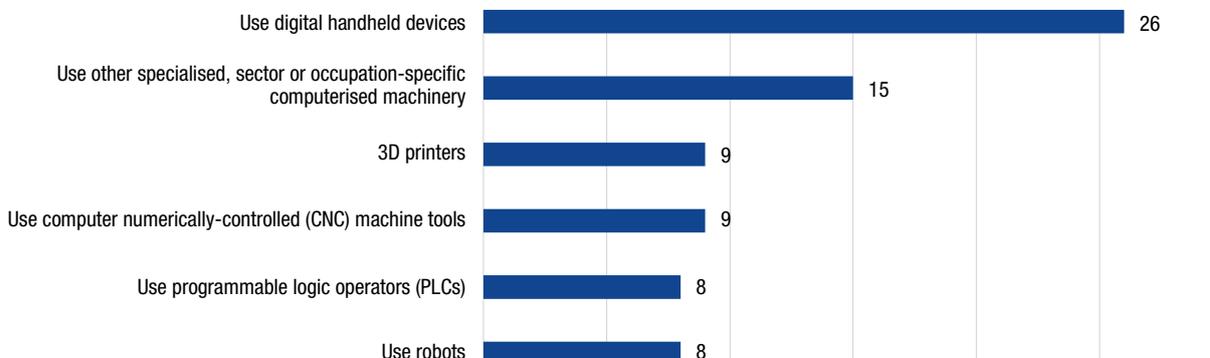
### 3.3.2. Cedefop digital skills intensity (DSI) index

The Cedefop digital skills intensity (DSI) index uses a composite indicator approach to characterise jobs in terms of the intensity of use of digital technologies at work in the 29 European countries covered by the survey. The index blends quantitative and qualitative technology intensity: the number of computer applications Europeans use in their jobs and their skill complexity<sup>(9)</sup>.

<sup>(9)</sup> The DSI does not consider the type and frequency of use of different computerised machines, given that such information was only collected for the online component of the ESJS2 sample. Principal components analysis also reveals that the information on computerised machines use is distinct from that focused on computer activities. The DSI is therefore likely to underestimate the extent of digital skill demand in countries that make greater use of computer-based machines. See Annex 3 for more methodological information.

Figure 14. Use of computerised machines in main job by equipment type, EU+

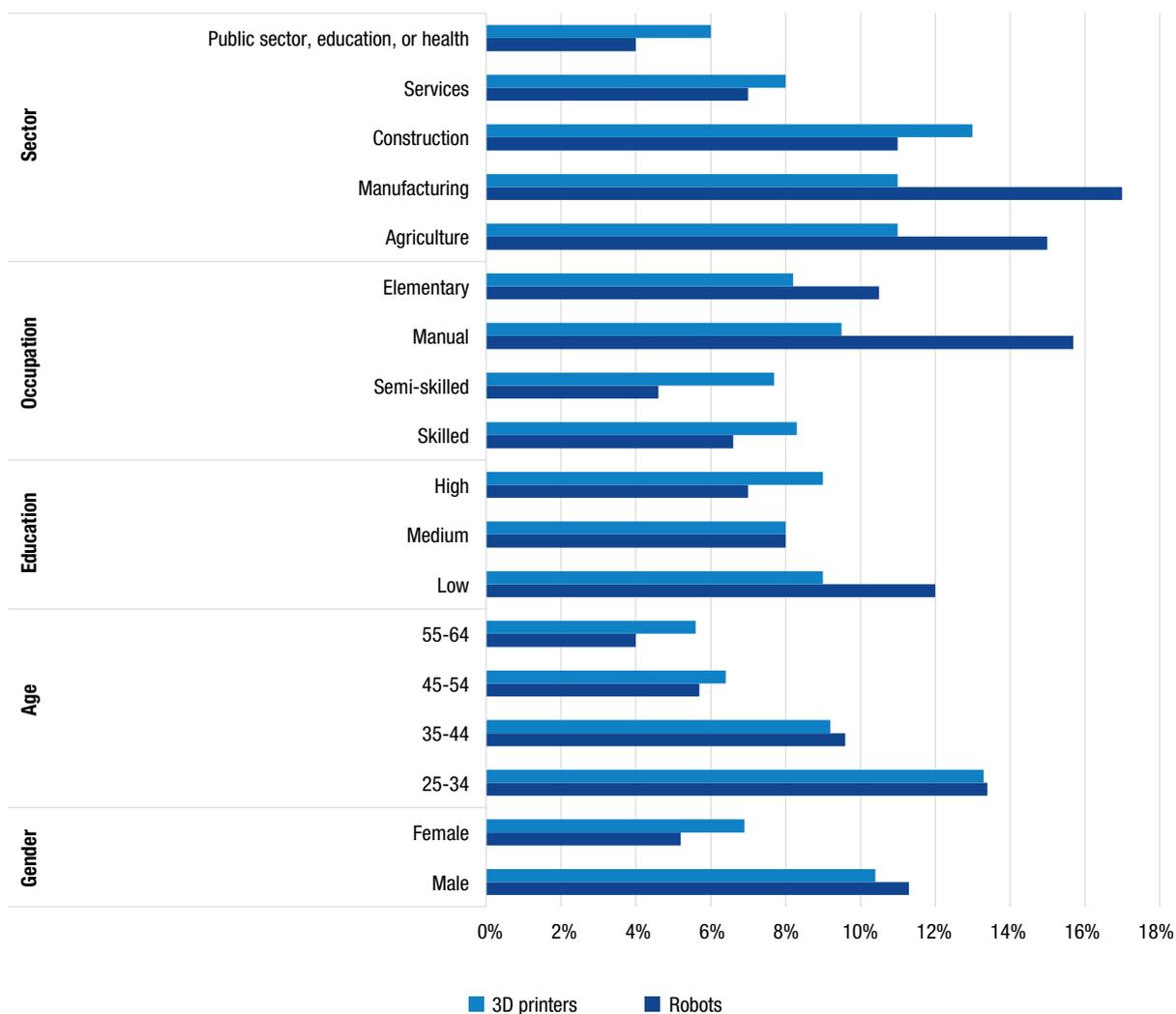
**D\_CM:** AS PART OF YOUR MAIN JOB, DID YOU WORK WITH OR OPERATE ANY OF THE FOLLOWING COMPUTERISED MACHINERY IN THE LAST MONTH?



NB: Only online ESJS2 survey participants were asked the question about the use of computerised machines; no data are available for Cyprus and Malta; weighted data.

Source: Cedefop second European skills and jobs survey, 2021.

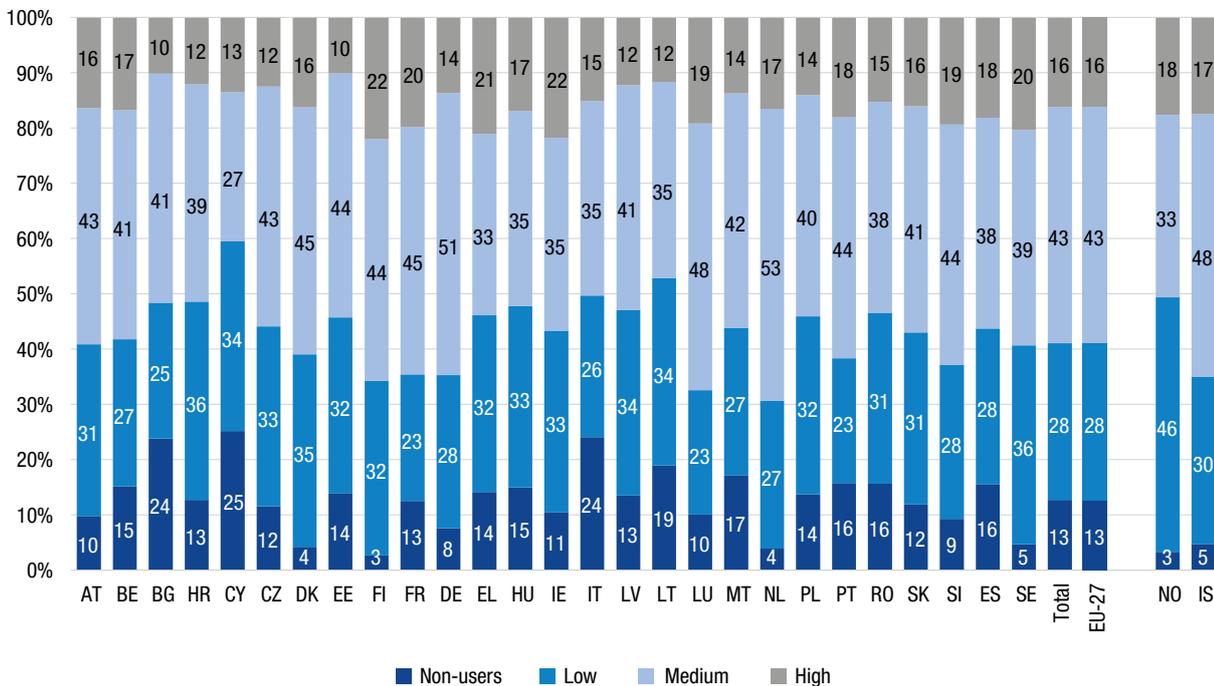
Figure 15. Users of robots and 3D printers in the EU+



NB: Only online ESJS2 survey participants were asked the question about the use of computerised machines; no data are available for Cyprus and Malta; weighted data.

Source: Cedefop second European skills and jobs survey, 2021.

Figure 16. Cedefop digital skills intensity (DTI) index, EU+ countries



NB: See Annex 3 for details of the methodology of index derivation.  
Source: Cedefop second European skills and jobs survey, 2021.

41% of European adult workers are in jobs that demand little or no use of computer technology (Figure 16). 13% do not use any digital devices at work, 10% are in jobs with a very low DSI (e.g. exclusively browsing the web, sending emails or using social media at work) and 18% are in jobs with a low DSI (e.g. using word-processing and spreadsheets or making presentations at work). 43% are employed in posts with a medium level DSI. Most of them carry out digital activities that require an intermediate level of skills complexity (e.g. using sector- or occupation-specific software, using formulas and macros in spreadsheets, or merging and managing databases) that they carry out alongside more basic digital tasks <sup>(4)</sup>. The remaining 16% of the EU+ workforce engage with advanced digital technology at work, such as computer programming, including the use of AI algorithms, and ICT system maintenance and development.

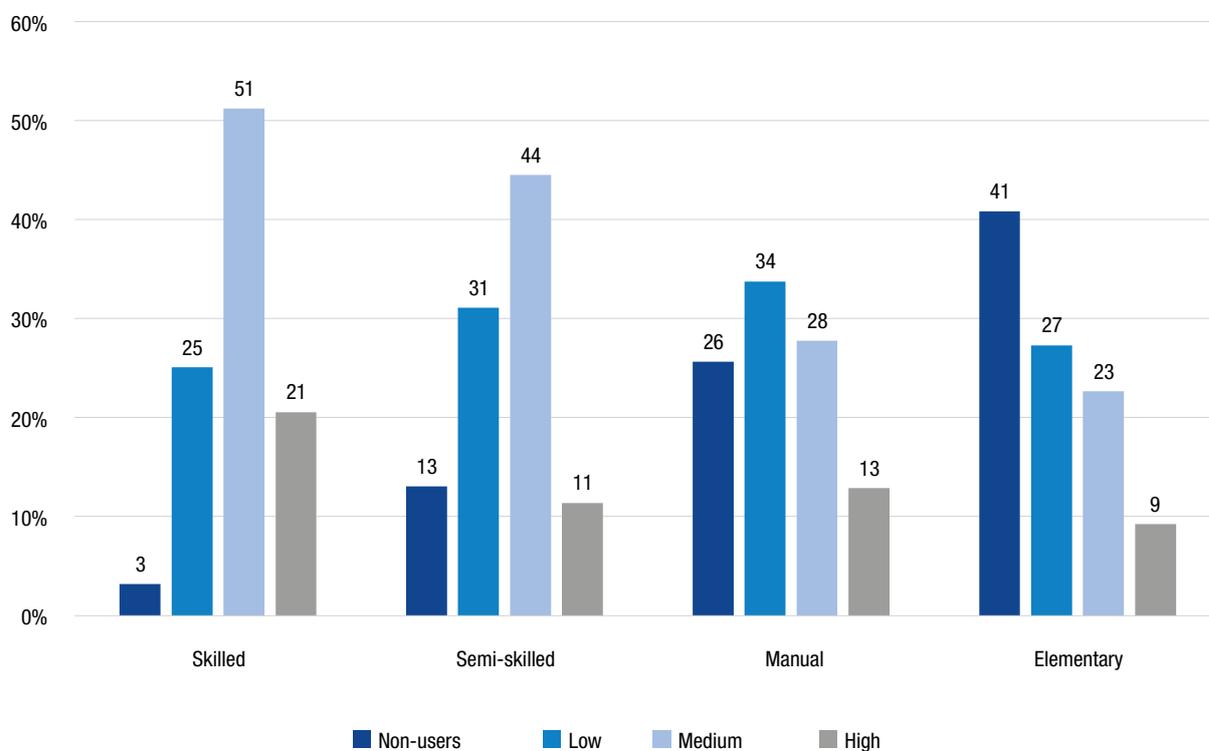
The distribution of jobs in terms of digital technology intensity underpinning digital skill demand

in EU+ economies is comparable to what has been reported by other international and EU surveys, including the first European skills and jobs survey (Cedefop, 2015a, 2018a; Centeno et al., 2022). They point towards significant scope to further digitalise many jobs in Europe, given that six in 10 EU+ workers carry out relatively basic or low-intensive digital tasks at work, and one in eight none. The results are also consistent with those found based on surveys of industrial companies, which suggest that – while investment in digitalisation is widespread – only a minority of companies consider their factories fully digitalised (Kinkel et al., 2022). Although it is difficult to compare different data sets and results due to differences in definitions and methodologies (Centeno et al., 2022), there are signs this trend may be changing. The share of European workers engaging in more moderate or advanced digitally intensive activities appears to be on the rise following the COVID-19 shock <sup>(5)</sup>.

<sup>(4)</sup> About half of these employees (21% of the total EU+ workforce, indicated as ‘low-medium’) work with only one to four digital applications at work. At least one of these requires medium level digital skills.

<sup>(5)</sup> The first ESJS, carried out in 2014, indicated that about 28% of EU-27+UK adult workers did not need any ICT skills at work, or required only a very basic level. 52% needed a moderate level of digital skills to carry out their job, while about 14% carried out advanced ICT activities. The comparable ESJS2 statistics would be 23% (no or very low digital use), 61% (moderate digital intensity) and 16% (high digital intensity).

Figure 17. Cedefop digital skills intensity (DTI) index by occupational group



Source: Cedefop second European skills and jobs survey, 2021.

European countries with the largest shares of no or very low digital intensity jobs include Cyprus (60%), Lithuania (53%), Italy (50%), Norway (49%), Croatia (49%), Bulgaria (48%) and Hungary (48%). The share is much lower in the Netherlands (31%), Luxembourg (33%) and Finland (34%). Finland (22%), Ireland (22%), Greece (21%), Sweden (20%) and France (20%) lead the ranks when it comes to the proportion of jobs demanding an advanced digital skill level.

Digital intensity also varies greatly by industry and occupation (Figure 17). Reflecting complementarity between skills and digital technology, the more skilled occupations are also the more digitally intense ones. The difference is most pronounced between workers in skilled occupations, where 72% are in jobs that are at least of medium digital intensity, and those in elementary occupations, where only 32% carry out tasks of a similar digital skill complexity. The share of low digital intensity jobs is highest in manual occupations<sup>(6)</sup>. Over 30% of adults employed in the accommo-

dation and food service, mining and agricultural sectors do not use digital devices at work at all. Adults working in the ICT, finance or professional scientific services sector are typically in jobs demanding an advanced digital skill level.

Multivariate empirical analysis (Section 3.5) shows that, apart from requiring higher digital skills, digitally intense jobs also demand higher complementary foundation (e.g. literacy, numeracy), cognitive (e.g. problem-solving, creativity) and social skills, even among people in the same broad occupational group.

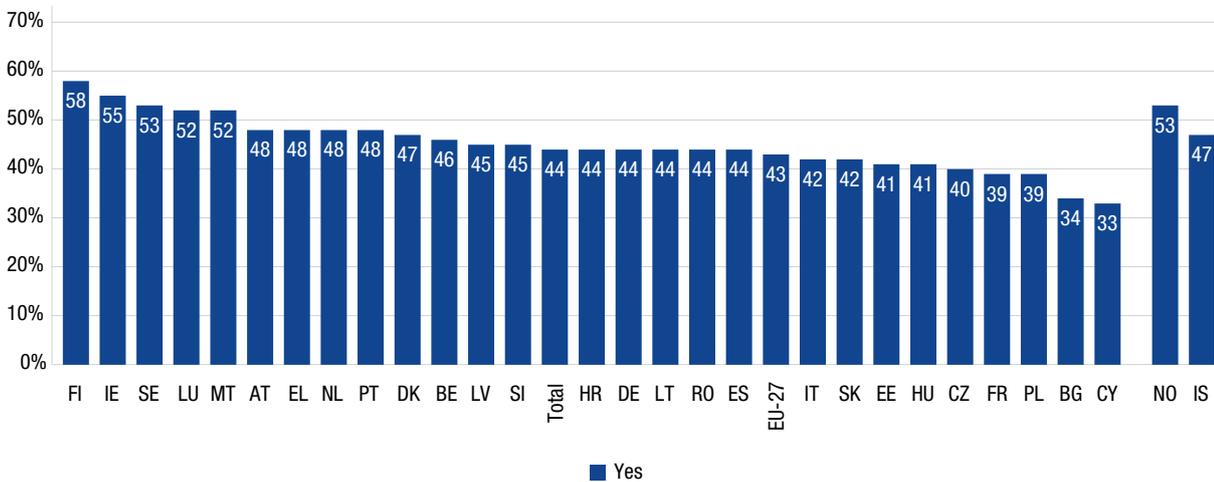
### 3.4. Technological change in the workplace

The rapid change in technical skills requirements at work observed in recent decades – which reflects skills obsolescence and renewal – suggests that the pace of introduction of ‘new’ technologies at work is high (Deming and Noray, 2020).

<sup>(6)</sup> As noted above, the level of digital sophistication required in manual jobs may be underestimated, because computerised machine use is not part of the index.

Figure 18. Introduction of new digital technologies in EU+ workplaces, 2020-21

**B\_CHORTECH:** DID ANY OF THE FOLLOWING CHANGES TAKE PLACE IN YOUR WORKPLACE? NEW DIGITAL TECHNOLOGIES I.E. NEW COMPUTER SYSTEMS/ COMPUTER DEVICES/ COMPUTER PROGRAMMES



Source: Cedefop second European skills and jobs survey, 2021.

ESJS2 evidence makes it possible to shed light on the extent to which the EU’s long-standing digital transformation increased speed with the pandemic, in 2020-21. New digital technologies – new computer systems, computer devices or computer programmes – were introduced at the workplace of 44% of employees in the 12 months preceding the survey (Figure 18). More than five in 10 adult workers in north European countries (e.g. Finland, Sweden, Luxembourg), as well as Ireland and Malta, saw new digital technologies adopted in their workplace. Adopting new technology was less common in some south and east European Member States (e.g. Cyprus, Bulgaria, Poland), where three in 10 adult workers reported such innovations.

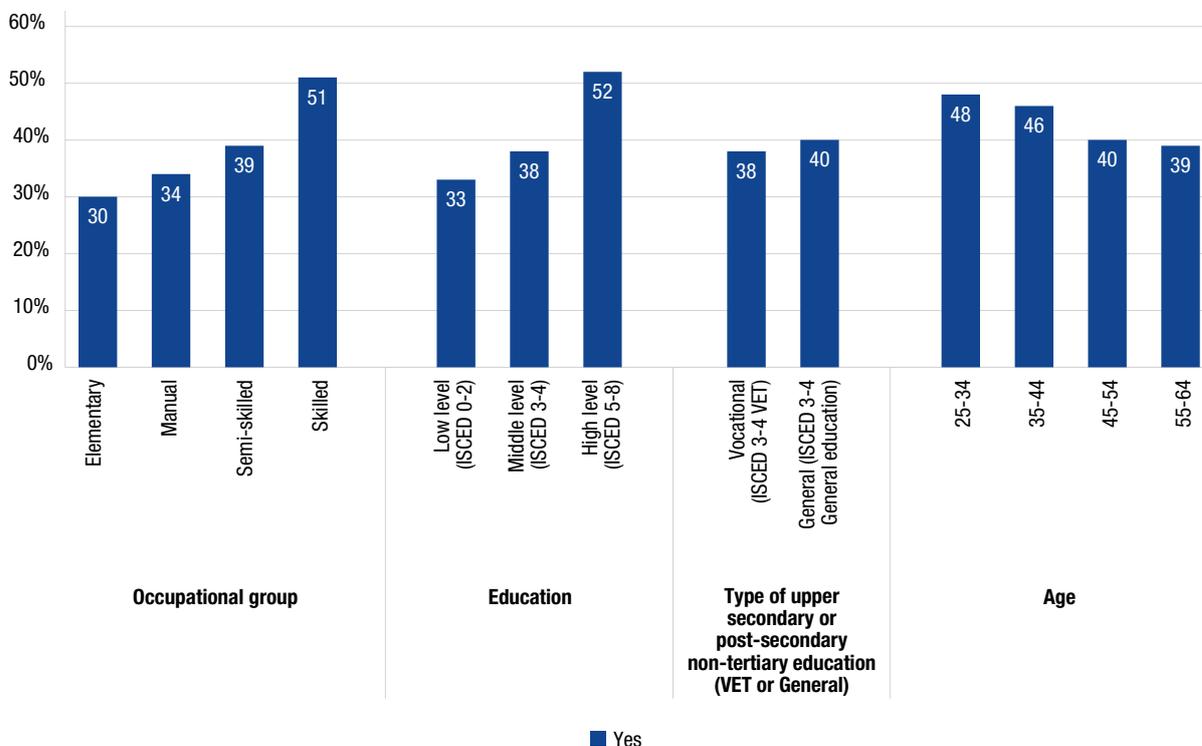
Similar to the case for the use of digital technologies, there is a marked skill bias in the uptake of new digital technologies at work (Figure 19). One in two workers in higher skilled occupations (51%), and also those with higher education (52%), was in a workplace where new digital technologies were recently introduced. This was much less common for those in manual (34%) or elementary (30%) occupations and for the low-educated (33%). Affecting 39% of them, older workers (55-64) were less exposed to new digital technologies at work than those aged 25-34 (48%). These results clearly illustrate the inequality in access to the newest technologies in European workplaces.

Slightly below general upper secondary education graduates, 38% of medium-educated VET graduates were confronted with new digital technologies at work. This underlines the importance of agile VET, which responds quickly when new computer-based devices and machines are introduced in workplaces. Staying ahead of the curve requires robust skills intelligence which, apart from real-time labour market signals, also incorporates longer term trends via technological skills forecasting or foresight (Cedefop, 2021a,b,c). Investing in the digital infrastructure of schools and digital training for VET staff (Cedefop, 2020c) are also key.

Measuring new ICT technologies in EU+ workplaces by asking workers about their introduction may not fully capture their wider diffusion in organisations and may overestimate their impact on jobs. Much technological innovation involves routine or minor (software) upgrades to computer systems, which do not have tangible impacts on staff upskilling or reskilling needs. Even when technological change can be considered significant, as with an organisation introducing artificial intelligence (AI), it may be less pervasive than initially thought. Organisations often encounter difficulties deploying AI technology cross-functionally across different organisational layers and teams. Many non-managerial jobs are left unaffected by it, or staff remain oblivious to its potential benefits for

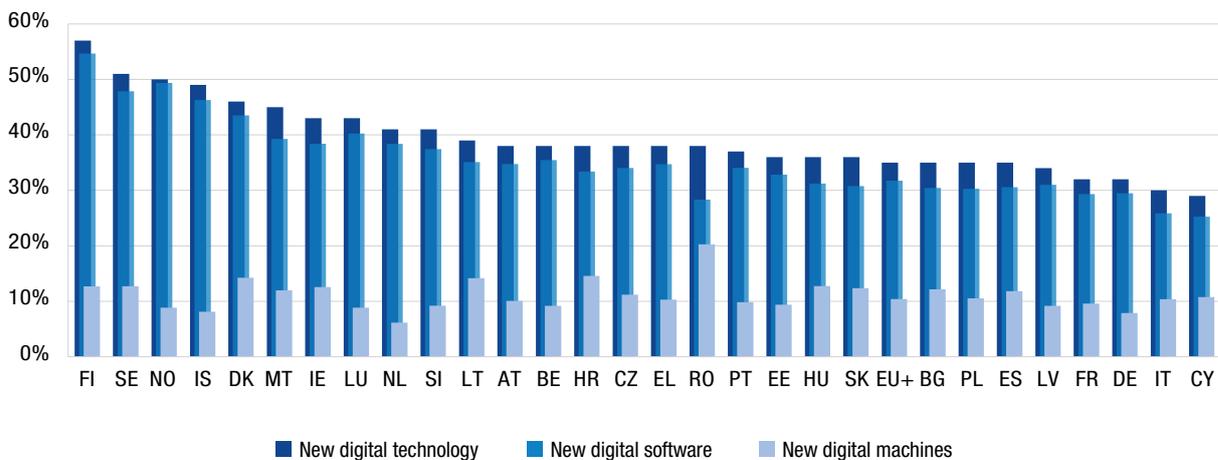
Figure 19. **New digital technologies in EU+ workplaces by socioeconomic characteristics, 2020-21**

**B\_CHORTECH:** DID ANY OF THE FOLLOWING CHANGES TAKE PLACE IN YOUR WORKPLACE? NEW DIGITAL TECHNOLOGIES I.E. NEW COMPUTER SYSTEMS/ COMPUTER DEVICES/ COMPUTER PROGRAMMES



Source: Cedefop second European skills and jobs survey, 2021.

Figure 20. **Digital upskilling in EU+ jobs, 2020-21**



NB: See Box 4 for corresponding ESJS2 questions.

Source: Cedefop second European skills and jobs survey, 2021.

**Box 4. Measuring digital upskilling in the EU+ labour market**

To proxy EU+ worker digital upskilling in the period 2020-21, two variables were combined. These measure the extent to which digital technology users had to learn how to use new digital technologies for their job and were obtained by asking ESJS2 respondents the following two questions:

**Computer software**

*In the last 12 months (for those with more than 1 year of employer tenure) / Since you started your main job (for new entrants), did you learn to use any new computer programmes or software to do your main job? Please exclude minor or regular updates.*

By 'new' we mean those you started using for your main job in the last 12 months. Consider any computer programmes or software, either general or specialised or occupation-specific (e.g. Microsoft Office, database management, multimedia editors, communication apps, enterprise resource planning, data analysis). Do not include computer programmes or software that you had to learn for other purposes, such as other or prior jobs or social or recreational activities. Only include major updates to any computer programmes or software you use to do your main job.

**Computerised machines**

*In the last 12 months (for those with more than 1 year of employer tenure) / Since you started your main job (for new entrants), did you learn to use any new computerised machinery to do your main job? Please exclude any minor or regular updates.*

By 'new' we mean those you started using for your main job in the last 12 months. For instance, digital handheld devices, CNC machine tools, robots, PLCs, 3D printers or any other specialised, sector or occupation-specific computerised machines. Do not include instances where you had to learn to use any computerised machinery for other purposes, such as other or prior jobs or social or recreational activities. Only include major updates to any computerised machinery you use to do your main job.

Source: Cedefop second European skills and jobs survey, 2021.

their work (Johnk et al., 2020; Jaismal et al., 2021).

To understand the real skilling impact of technology on workers, the ESJS2 uses a measure linking major technological innovation to upskilling or reskilling needs. The survey asked digital technology users at work whether they had to learn to use any new digital technologies – computer programmes, software, or computerised machines – to do their main job (Box 4) <sup>(7)</sup>.

One in three (35%) EU+ employees had to learn to use new digital technologies (excluding any minor or regular updates) to do their main job in the year preceding the survey (Figure 20). This measure combines the 32% of European workers who – for job-related purposes – had to

learn new computer programmes or software and the 10% who had to master new computerised machines <sup>(8)</sup>.

Learning new computer programmes or software is most prevalent among adult workers in Finland (55%) and in other Nordic countries, such as Sweden, Denmark, Iceland and Norway (Figure 20). Upskilling to learn how to work with new computer programmes or software is far less common in Cyprus (25% of adult workers), Italy (26%), Romania (28%), France and Germany (both 29%). The need to learn new computerised machines ranges from 20% (of adult workers) in Romania to 6% in the Netherlands. The sectoral distribution of employment, prior digital skills of

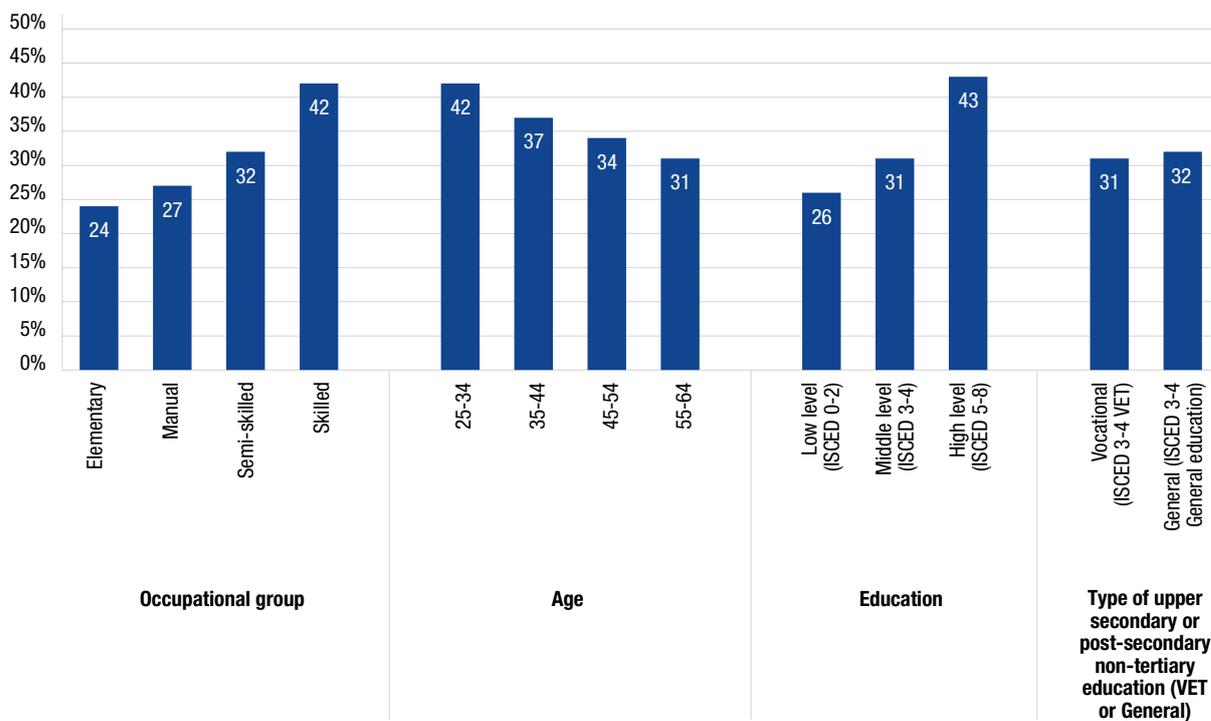
<sup>(7)</sup> ESJS2 analysis shows that almost half (46%) of EU+ workers who were confronted with new digital technologies in their workplace in the year preceding the survey did not have to learn themselves how to use new computer software or computer-based machines.

<sup>(8)</sup> When focusing only on the users of computing devices the corresponding figure is 36%, while for users of computerised machines the respective share is 20%.

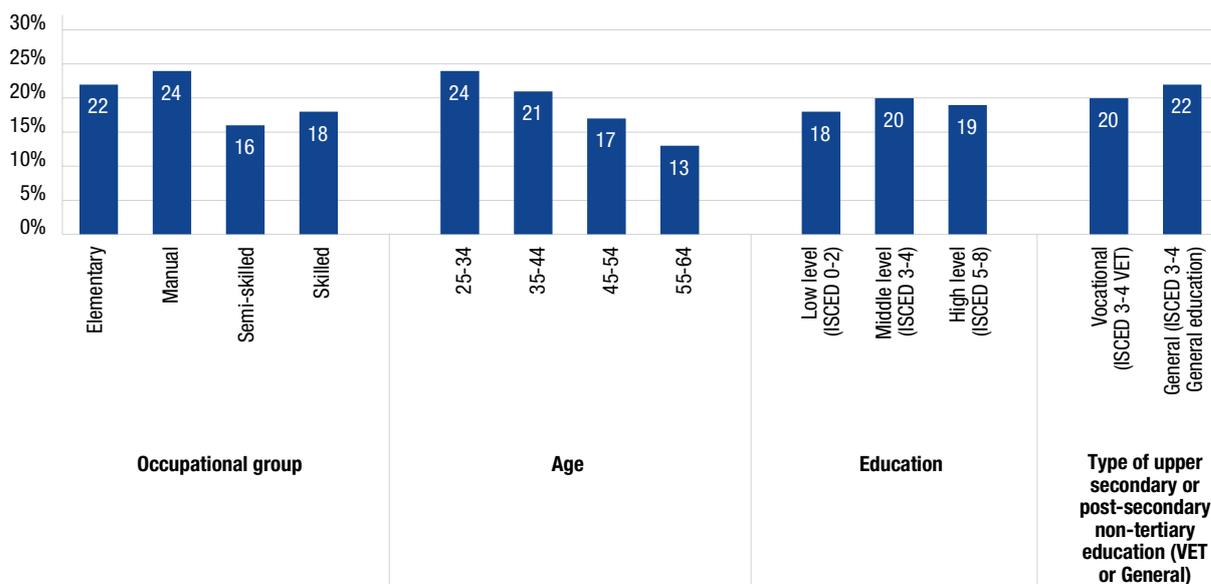
Figure 21. Digital upskilling of EU+ workers by socioeconomic characteristics, 2020-21

**(a) Computer programmes or software**

**D\_CHSFW:** IN THE LAST 12 MONTHS/SINCE YOU STARTED YOUR MAIN JOB, DID YOU LEARN TO USE ANY NEW COMPUTER PROGRAMMES OR SOFTWARE TO DO YOUR MAIN JOB? PLEASE EXCLUDE MINOR OR REGULAR UPDATES.

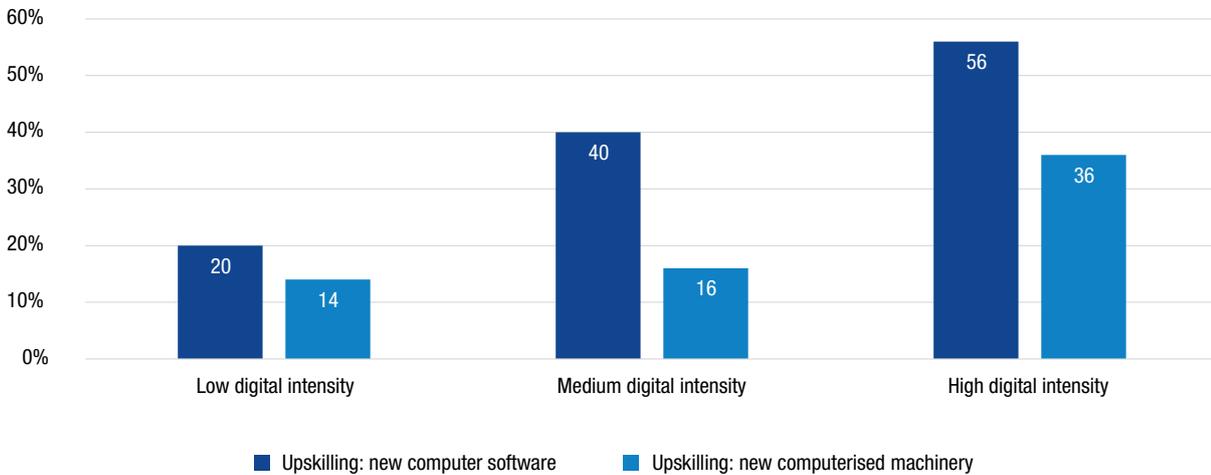
**(b) Computerised machines**

**D\_CHCM:** IN THE LAST 12 MONTHS /SINCE YOU STARTED YOUR MAIN JOB, DID YOU LEARN TO USE ANY NEW COMPUTERISED MACHINERY TO DO YOUR MAIN JOB? PLEASE EXCLUDE ANY MINOR OR REGULAR UPDATES.



NB: The population of graph (a) comprises individuals who are users of computer devices; for graph (b) it is users of computerised machines.  
Source: [Cedefop second European skills and jobs survey, 2021](#).

Figure 22. Digital upskilling in EU+ jobs by Cedefop DSI, 2020-21



NB: The shares are calculated using a sample of users of computer devices or users of computerised machines, respectively.  
Source: Cedefop second European skills and jobs survey, 2021.

the workforce, the digital readiness of firms and other factors largely determine the observed digital upskilling of adult workers and the differences between countries.

With 42% of employed adults in skilled professions engaging in digital upskilling to learn new computer programmes or software, and less than a quarter (24%) of those in elementary jobs doing so (Figure 21), it is obvious there is a positive link between this type of digital upskilling and the skill level of occupations. In contrast, it is mostly adults in manual (24%) and elementary (22%) occupations who had to learn to use new computerised machines, less so than those in skilled (18%) or semi-skilled (16%) occupations. No matter what the digital upskilling aims at, younger workers engage more in it than older workers. With a higher education level comes a greater likelihood of learning new computer software (43% of the higher-educated, versus 26% of the low-educated). No such 'education premium' is evident for upskilling aimed at learning to use new computerised machines.

Jobs with higher digital skills intensity (DSI) are more likely to require workers to master new computer software or computer-controlled machines (Figure 22). While only two in 10 employees in jobs with no or little digital intensity learned how to use new computer programmes, nearly six in

10 (56%) of those in very high digitally intensive jobs took part in such learning. A similar yet less pronounced pattern is evident for learning how to use new computerised machines (14% of workers in jobs with no or little digital intensity versus 36% of those in jobs with very high digital intensity).

These findings point to occupational, age-related and educational inequalities in access to learning new digital technologies. Apart from their immediate negative impact on skill matching, they should also be viewed as a longer-term problem. Over time, differences in digital knowledge and skills may widen as workers in more skilled and digitally intense jobs have significantly more opportunities to engage in further learning to cope with ongoing technological progress than those in less digital jobs.

### 3.5. Who are the European digital workers?

With the use of multivariate econometric models, it is possible to identify which individual and job characteristics of EU+ adult workers are positively associated with their probability of being in digital jobs, or jobs recently affected by technological change <sup>(9)</sup>.

The results (Table 2) show that non-users or low users of digital technologies, or those less likely to have engaged in digital upskilling, disproportionately comprise older (45+) and lower-educated persons. Females are less likely to be users of computer devices and of computer-controlled machines, reflecting the gender gap in STEM or related VET degree studies, and are typically employed in lower digital intensity jobs. Non- or low digital users are more likely to have shorter job tenure or hold temporary contracts, although such workers are more likely to have to learn new digital technologies than incumbent workers.

Although digital jobs are more often found in

the private sector, it is mostly public sector employees who had to upskill digitally in 2020-21. Individuals insulated from digital technologies are typically employed in smaller-sized firms. They are also more likely to be in lower-skilled, non-complex, jobs involving manual tasks and demanding a low level of foundation and social skills. Nonetheless, it is primarily manual workers who must learn to operate new computerised machines at work. There is also a positive association between the need to learn new digital technologies, particular computerised machines, and the routinisation of work (discussed in more detail in Chapter 4). The limited possibilities non-users of digital devices – and those not exposed to digital upskilling – have to exploit remote work marks their greater vulnerability to the social distancing realities imposed by the COVID-19 pandemic. Despite such circumstances, these priority groups for policy intervention are less likely to have received any education and training in their jobs, compared to those in digital jobs.

Table 2. EU+ workers using and learning digital technologies, 2020-21

	(1) Users of computer devices	(2) Higher digital intensity job	(3) Digital upskilling	(4) Digital upskilling – computer software	(5) Digital upskilling – computer machines
<b>Age group</b>					
35-44	-0.08* (0.045)	-0.14*** (0.033)	-0.10*** (0.018)	-0.08*** (0.014)	-0.10*** (0.029)
45-54	-0.21*** (0.059)	-0.28*** (0.033)	-0.11*** (0.023)	-0.08*** (0.029)	-0.19*** (0.036)
55-64 (ref: 25-34)	-0.29*** (0.058)	-0.35*** (0.025)	-0.11*** (0.027)	-0.06* (0.034)	-0.26*** (0.048)
Male	0.17*** (0.044)	0.23*** (0.019)	0.05** (0.024)	0.04 (0.028)	0.16*** (0.040)
<b>Education</b>					
Upper secondary or post- secondary, non-tertiary	0.13*** (0.031)	0.17*** (0.021)	0.12** (0.054)	0.10* (0.055)	0.03 (0.067)

<sup>(9)</sup> Table 2 illustrates the coefficients of discrete choice, probit and ordered probit, regressions. The first two columns present models explaining the likelihood of adult workers using any computing device to do their job (probit) or being in a higher digital intensity job (ordered probit). Columns 3-5 estimate models where the dependent variable is a dummy variable taking the value one for those who had to learn new, major digital software or new computerised machines in the last year for their job. Alongside key socio-demographic and job characteristics, the estimated models include summary indices of the level of skill requirements, work routinisation and complexity of EU+ jobs (Annex 3).

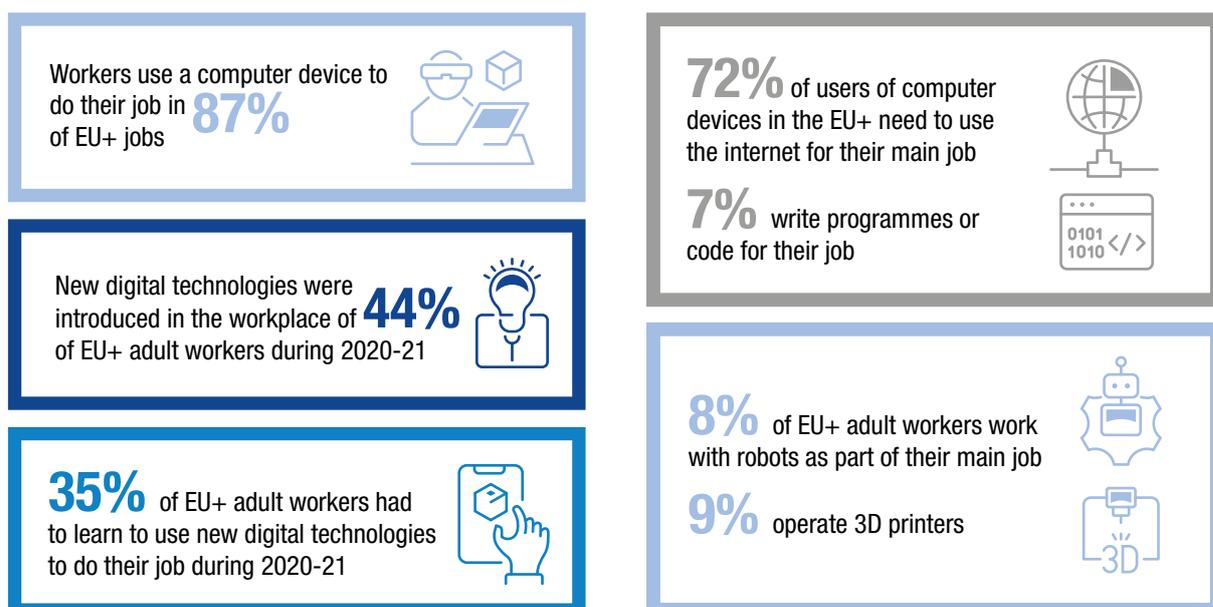
	(1) Users of computer devices	(2) Higher digital intensity job	(3) Digital upskilling	(4) Digital upskilling – computer software	(5) Digital upskilling – computer machines
<b>Education</b>					
Tertiary education (ref: Below upper secondary)	0.39*** (0.039)	0.21*** (0.021)	0.12*** (0.047)	0.12*** (0.042)	-0.05 (0.070)
Employer tenure (years)	0.01*** (0.002)	0.00*** (0.001)	-0.01*** (0.002)	-0.01*** (0.003)	-0.01** (0.002)
Private sector	0.04** (0.022)	-0.01 (0.021)	-0.10*** (0.028)	-0.08** (0.034)	-0.12*** (0.027)
SME	-0.10** (0.039)	-0.05** (0.019)	-0.10*** (0.015)	-0.10*** (0.018)	-0.00 (0.017)
Permanent contract	0.21*** (0.053)	0.14*** (0.030)	-0.11*** (0.020)	-0.06*** (0.018)	-0.19*** (0.038)
Weekly work hours	0.00*** (0.001)	-0.00 (0.001)	-0.00 (0.001)	-0.00* (0.001)	-0.00 (0.002)
Remote work	0.12*** (0.042)	0.09*** (0.018)	0.17*** (0.022)	0.19*** (0.024)	0.05** (0.023)
<b>Occupation</b>					
Professionals	-0.15 (0.140)	-0.00 (0.036)	0.05 (0.032)	0.07** (0.035)	-0.06 (0.057)
Technicians and associate professionals	-0.03 (0.136)	0.04 (0.051)	0.13*** (0.047)	0.15*** (0.043)	0.11** (0.052)
Clerical support	0.30 (0.188)	0.13*** (0.039)	0.15*** (0.025)	0.18*** (0.027)	-0.02 (0.052)
Service and sales	-0.59*** (0.091)	-0.32*** (0.032)	-0.11*** (0.036)	-0.12*** (0.038)	0.03 (0.081)
Skilled agricultural, forestry and fishing	-0.84*** (0.165)	-0.43*** (0.080)	-0.03 (0.069)	-0.18** (0.080)	0.22** (0.090)
Craft and related trades	-0.61*** (0.181)	-0.30*** (0.055)	0.03 (0.071)	-0.09 (0.062)	0.32*** (0.081)
Plant and machine operators and assemblers	-0.66*** (0.133)	-0.56*** (0.050)	-0.14 (0.086)	-0.26*** (0.072)	0.20* (0.100)
Elementary occupations (ref: Managers)	-0.76*** (0.102)	-0.51*** (0.038)	-0.12 (0.075)	-0.25*** (0.056)	0.24** (0.105)
<b>Job-skill requirements</b>					
Literacy skills	0.64*** (0.027)	0.25*** (0.010)	0.16*** (0.010)	0.18*** (0.008)	0.14*** (0.022)
Numeracy skills	0.26*** (0.028)	0.23*** (0.014)	0.11*** (0.013)	0.11*** (0.019)	0.11*** (0.018)
Social skills	0.32*** (0.028)	0.21*** (0.024)	0.12*** (0.028)	0.11*** (0.019)	0.18*** (0.034)
Manual skills	-0.39*** (0.046)	-0.07** (0.027)	0.07** (0.034)	-0.04 (0.023)	0.54*** (0.055)
<b>Work organisation</b>					

	(1) Users of computer devices	(2) Higher digital intensity job	(3) Digital upskilling	(4) Digital upskilling – computer software	(5) Digital upskilling – computer machines
Job complexity	0.12*** (0.039)	0.10*** (0.023)	0.22*** (0.041)	0.21*** (0.033)	0.12*** (0.040)
Work routinisation	-0.07** (0.029)	-0.00 (0.018)	0.03* (0.015)	0.02* (0.013)	0.10*** (0.022)
Education or training	0.18*** (0.019)	0.24*** (0.012)	0.60*** (0.016)	0.58*** (0.028)	0.52*** (0.050)
CATI dummy	-0.15*** (0.040)	-0.19*** (0.024)	0.16*** (0.027)	0.11*** (0.030)	0.03 (0.058)
Country dummies	x	x	x	x	x
Industry dummies	x	x	x	x	x
Intercept: low DSI		0.59*** (0.220)			
Intercept: medium DSI		1.84*** (0.179)			
Intercept: high DSI		3.37*** (0.155)			
Constant	-1.02*** (0.206)		-2.22*** (0.113)	-2.36*** (0.098)	-3.07*** (0.177)
<b>Observations</b>	<b>42 392</b>	<b>42 392</b>	<b>42 392</b>	<b>42 392</b>	<b>42 392</b>

NB: Robust standard errors in parentheses, clustered by country; \*\*\* p<0.01, \*\* p<0.05, \* p<0.1. Description of the derivation methodology of the job-skill requirements and work organisation indices are available in Annex 3. Weighted data.

Source: Cedefop second European skills and jobs survey, 2021.

### Key ESJS2 statistics on digitalisation in the EU+



Source: Cedefop second European skills and jobs survey, 2021.

# Understanding the changing nature of work

## 4.1. Upskilling or deskilling?

More workers were exposed to new digital technologies during the pandemic and most companies implemented changes in their core business activities (van Loo et al., 2021). As these developments amplified long-term digitalisation trends, it is often suggested (digital) skill demands in Europe are rising. ESJS2 analysis helps provide insight into whether such claims are justified, and if so, to what extent.

In earlier economic literature, technological change was typically considered a complement to high-skilled labour, elevating job-skill requirements and accentuating earnings inequalities (Katz and Murphy, 1992; Autor et al., 1998). Others have refuted this skill-biased technological change (SBTC) hypothesis by arguing that digital technology can more easily automate tasks in middle-skill jobs than those in jobs at the higher and lower end of the employment market (Autor et al., 2003). Viewing technological change as routine biased (RBTC) can help explain the trend towards greater job polarisation observed in previous decades in the U.S and some parts of Europe (Goos and Manning, 2007; Goos et al., 2009, 2014).

Cutting-edge artificial intelligence (AI) and robotics go far beyond traditional rule-based approaches to computer programming, changing the notion of what can be considered 'routine' in work. They place within reach of machines and computer technology a wide range of cognitive and even social (language) job tasks that were long considered impossible to automate (Bazylik and Gibbs, 2022).

Approaches to map 'routineness' and to investigate how it impacts the labour market have been challenged. Ambiguity in measuring the 'routine' intensity of jobs (Sebastian and Biagi, 2018), the use of broad and imperfect occupational proxies of job-skill requirements (Handel, 2017) and the

absence of a clear polarisation trend in several European economies (Antonczyk et al., 2009; Green 2012; Fernandez Macias and Hurley, 2017; Oesch and Piccitto, 2019) have been used as arguments to contest the RBTC hypothesis.

There are several mechanisms linking the introduction of computers and other digital technology to job-skill demands and wage inequality. Skill requirements may rise because the occupational distribution of employment shifts, increasing demand for high-skilled occupations relative to lower skilled ones, even if the content of most jobs remains relatively unchanged. This can happen because introducing digital technology may require a greater number of skilled workers to manage it (e.g. programmers, technicians, maintenance workers) or to analyse the information it generates (e.g. accountants, market researchers, data analysts). Digital technology also reduces the number of less-skilled workers in jobs it can fully automate (e.g. data entry clerks, telephone operators).

Much research centred around the RBTC hypothesis focuses on such between-occupation effects and pays less attention to how digital technology impacts skill requirements within occupations by altering task content within jobs. Part of the observed changes may reflect the simple fact that learning to operate digital equipment is difficult, implying a higher demand for skilled workers who can do so. The character of work may also change in the transition from manual or repetitive jobs to work where conceptual or abstract tasks matter more. To capitalise on the decentralised information possibilities modern digital technology offers, firms may restructure the work roles and tasks of front-line workers. Calling upon such workers to take on more decision-making and problem-solving responsibilities, formerly reserved for more skilled workers, can help empower them.

Despite the prevailing rhetoric of new digital technology raising skill requirements, they could

also lower skill needs via deskilling and work standardisation (Braverman, 1998). The roll-out of conventional digital technology in organisations may increase the time workers spend on repetitive data entry tasks. Much professional work also involves routine tasks, such as manually reviewing and coding electronic documents. In traditional (physical) work settings such as large warehouses, using robots to deliver items to human packers with machine-driven efficiency increases workload and job repetitiveness. ‘Algorithmic management’ (Kellogg et al., 2020) and task fragmentation has similar impacts on platform micro-workers and gig workers (Cedefop, 2021d).

These technology-driven changes in the labour market increase management control over work methods and pace, limiting, and in some cases even disabling, autonomous decision-making and task discretion. The way employers reacted to the COVID-19 pandemic is a case in point. While most EU firms aimed at expanding job autonomy during the pandemic, four in 10 organisations still chose to manage staff by controlling the tasks assigned to them (van Loo et al., 2021). The obvious lack of a high-investment, high employee-involvement approach to work organisation makes such companies less dynamic: they were least likely to see extensive changes in knowledge and skill needs.

Understanding the various forces impacting jobs and skills and how they may combine, counteract, or reinforce one another is essential for gaining insight into what has been called a paradox in EU job markets: fewer routine jobs (in terms of shifting workforce shares between different occupations) at times where work is becoming more routinised within-occupations (Eurofound, 2016; Freeman et al., 2020).

The second European Skills and Jobs Survey (ESJS2) provides robust evidence to shed light on the ambiguity surrounding the potential impact of digital technologies on labour markets, skill demands, and the nature of work. Understanding whether the proliferation of digital technology in

Europe goes hand-in-hand with jobs becoming more complex, or fosters work routinisation and task standardisation, is crucial for evidence-based employment and skills policy. Summarising key lessons learned from the ESJS2, this chapter focuses on the transformation of job tasks, job-skill complexity and the broader changes in work organisation and job quality implied by the introduction of new digital technologies in workplaces.

## 4.2. Job automation or task transformation?

### 4.2.1. Digitalisation and changing workplace size

The debate on the impact of digitalisation in labour markets and societies is at times dominated by technological alarmism, which paints a bleak picture of a ‘jobless future’. In this context, ESJS2 provides insight into the extent to which fears of robots or machines massively replacing workers are justified by evidence. According to the RBTC hypothesis, digitalisation, especially robotic process automation, hollows out routine, manual jobs. Tasks in such jobs can be codified and tacit knowledge is lower compared to high-skilled, or professional occupations. Robots substituting humans is viewed as the root cause of technological unemployment and job polarisation in advanced economies.

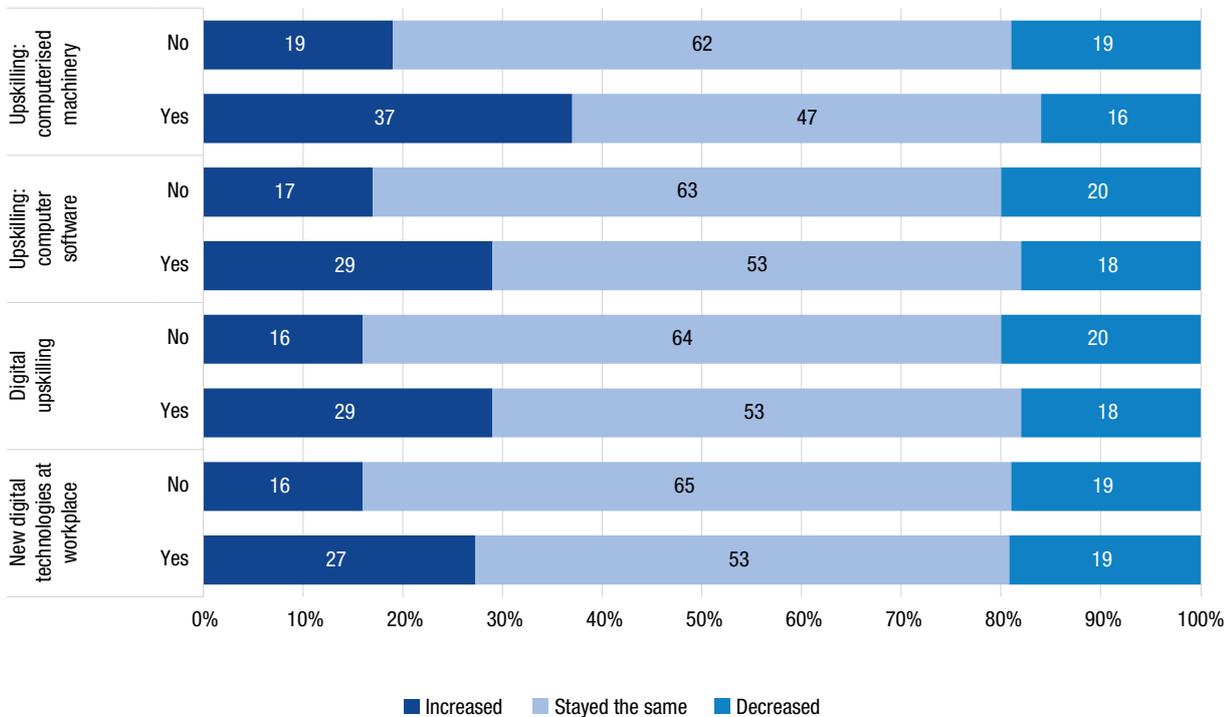
The ESJS2 cannot provide evidence on wider, system-level dynamics underlying the potential job destruction attributed to digitalisation: it is a cross-sectional survey of employees who have either survived technological labour-displacement or managed to return to the labour market if they were affected by it. Nevertheless, the survey makes it possible to link technological change to firm downsizing due to automation or other factors <sup>(10)</sup>.

The introduction of new digital technologies in workplaces is more common in (larger-sized)

<sup>(10)</sup> Workers were asked to report how they have been affected by technology adopted within their workplace, including whether they anticipate losing their job in the short- to medium-term. However, changes in employment due to technological change can be driven by shifts in the composition of jobs across establishments. If the workforce contracts in less technologically advanced establishments due to competition from more advanced ones, it is likely that displaced workers will be unaware of the underlying reason for their job loss. This exemplifies the limitations affecting any survey among workers: workers can provide information about their own workplace and job, but it is unreasonable to expect them to have detailed knowledge about other workplaces or system-level dynamics.

Figure 23. Digitalisation and change in workplace size, EU+, 2020-21

**B CHSIZ:** OVERALL, DID THE NUMBER OF PEOPLE WHO WORK AT YOUR WORKPLACE INCREASE, STAY ABOUT THE SAME OR DECREASE IN THE LAST 12 MONTHS (FOR THOSE WITH EMPLOYER TENURE MORE THAN ONE YEAR) / SINCE YOU STARTED WORKING THERE (FOR NEW ENTRANTS)?



NB: Online ESJS2 respondents only; weighted data.

Source: Cedefop second European skills and jobs survey, 2021.

workplaces with staff increases over the previous year (Figure 23). In a context of great labour market uncertainty and turmoil due to COVID-19 and the public health measures aimed at containing it, 27% of EU+ workers confronted with new digital technology in their workplace saw the size of their workplace grow over the year. This was the case for only 16% of adults employed in firms without digital innovation, who were more likely to work for companies with stable staff numbers. This shows that companies embracing the ‘digitalisation push’ managed better to survive the coronavirus shock and thrived. The increase in workplace size was particularly pronounced for adults who had to learn to use new computerised machines to do their job, a type of technology commonly associated with automation.

ESJS2 analysis does not support the assertion that taking up new digital technologies in the first year of the pandemic coincided with staff cuts and a net negative employment balance, as would be expected with abrupt automation. While this is an important finding, longer term automation effects

not captured by the ESJS2 can challenge it. It may take time before the full impact of investment in automation unfolds and becomes visible in capital for labour replacement. Significant changes in staff composition within growing, digital firms (e.g. new entrants versus incumbents), as reported in other empirical studies (Dauth et al., 2017; Bessen et al., 2020), may also take place.

#### 4.2.2. Digitalisation and job-task churning

Recent empirical analysis shows that technological change only replaces parts of – not entire – occupations (Arntz et al., 2017; Nedelkoska and Quintini, 2018; Pouliakas, 2018). New technologies change the allocation of job tasks between machines and workers. While displacing labour in some tasks, at the same time they increase productivity and contribute to labour demand in non-automated tasks (including those created by technology) where labour has a comparative advantage. The dynamics between labour displacement and the ‘reinstatement effect’ – the reinstatement of labour into a broader range of

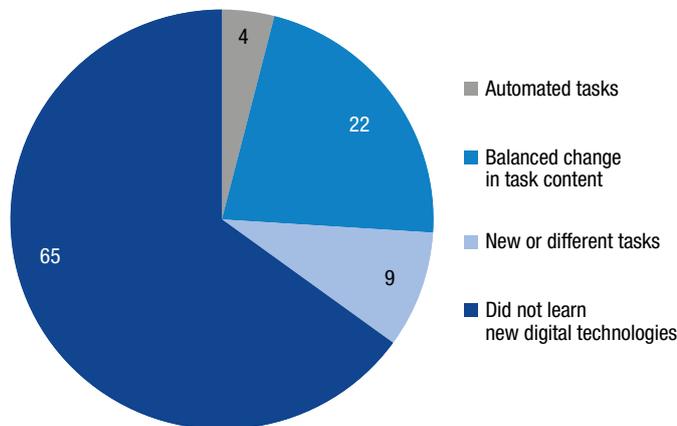
new tasks (Acemoglu and Restrepo, 2019) – are important because they affect productivity, employment, and wage growth. To capture them, the ESJS2 asked workers to state whether and how new digital technology changed the task composition in their job.

The large share of workers fearing the potential job- or skills-displacing impact of digital technologies (Chapter 1) is at odds with actual task automation in jobs. Only 14% of EU+ workers do not perform some tasks they did before, because of new digital technologies in their workplace. Male and lower-educated workers are more likely to be affected by task automation. They are typically employed in manual and low-skilled elementary jobs, which entail much routine work, in larger-sized firms and in particular sectors, such as agriculture, utilities, financial and insurance activities or accommodation and food services (Table 3).

Most workers experiencing task displacement simultaneously had to do some different or new tasks (Figure 24). This implies that only 4% of the EU+ workforce saw some of their job tasks being replaced by new digital software or machines without task expansion in other fields. 22% experienced task generation and destruction, while 9% only assumed new or different tasks. This demonstrates that digitalisation of work results in a dynamic reallocation of job tasks and a re-design of job content, not only substituting tasks by machines but also reinstating them.

Figure 24. **Digitalisation and task automation of EU+ jobs**

**D\_CHJOB:** AS A RESULT OF THE NEW COMPUTER PROGRAMMES OR SOFTWARE/NEW COMPUTERISED MACHINERY YOU LEARNT FOR YOUR MAIN JOB IN THE LAST 12 MONTHS, DID YOUR JOB TASKS CHANGE IN ANY OF THE FOLLOWING WAYS? (I) YOU NOW DO NOT DO SOME TASKS YOU DID BEFORE (II) YOU NOW DO SOME DIFFERENT OR NEW TASKS (III) YOU NOW DO SOME OF YOUR TASKS AT A FASTER PACE THAN BEFORE.



Source: Cedefop second European skills and jobs survey, 2021.

Table 3. **Task automation by socioeconomic characteristics, EU+, 2021**

<b>Gender</b>	Male	41%
	Female	37%
<b>Age</b>	25-34	41%
	35-44	41%
	45-54	37%
	55-64	36%
<b>Education</b>	Low	48%
	Medium	39%
	High	38%
<b>Occupation</b>	Skilled	38%
	Semi-skilled	36%
	Manual	45%
	Elementary	43%
<b>Sector</b>	Agriculture, forestry and fishing	50%
	Mining and quarrying	45%
	Manufacturing	41%
	Electricity, gas, steam and air conditioning supply	41%
	Water supply; sewerage, waste management and remediation activities	47%
	Construction	42%
	Wholesale and retail trade; repair of motor vehicles and motorcycles	36%
	Transportation and storage	43%
	Accommodation and food service activities	44%
	Information and communication	40%
	Financial and insurance activities	45%
	Real estate activities	38%
	Professional, scientific, and technical activities	42%
	Administrative and support service activities	41%
	Public administration and defence; compulsory social security	37%
	Education	31%
	Human health and social work activities	33%
	Arts, entertainment and recreation	37%
	Other service activities	32%
<b>Firm size</b>	1-10	37%
	>250	40%

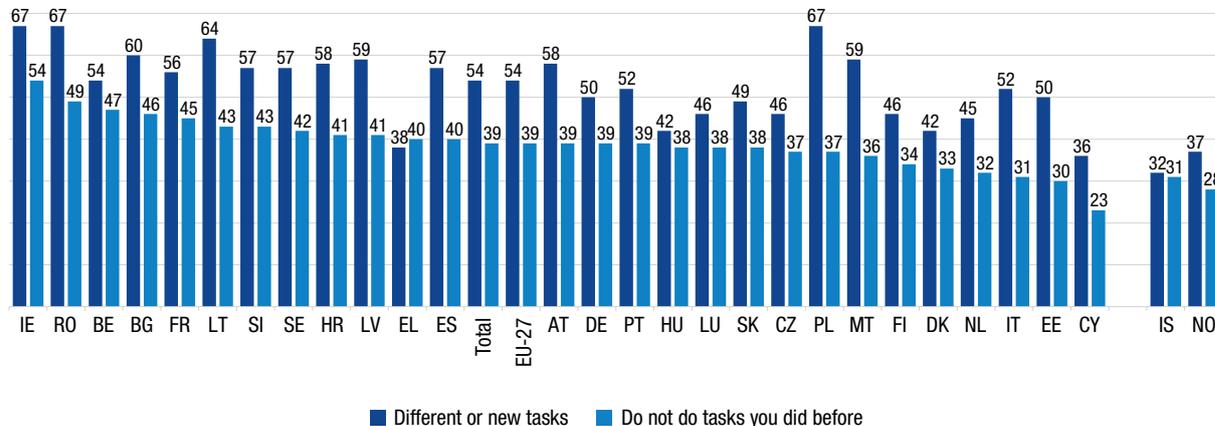
NB: Share of EU+ adult workers who had to learn new digital technologies and now do not do some tasks they did before.  
Source: Cedefop second European skills and jobs survey, 2021.

When technology does not destroy or create new jobs altogether, the overall impact of digitalisation on the task structure of jobs tends to be the addition of new tasks, usually but not always accompanying the replacement of others. Among those who had to learn new computer software or

computer-based machines in the first year of the pandemic, about four in 10 (39%) saw some of their job tasks completely replaced by new technology. For 54% of those exposed to new technology, it added new tasks to their job. Digitalisation also enables most workers (59%) to do their job

Figure 25. Change in job tasks due to digitalisation by country, EU+, 2020-21

D\_CHJOBDISP / D\_CHJOBNEW: AS A RESULT OF THE NEW COMPUTER PROGRAMMES OR SOFTWARE/NEW COMPUTERISED MACHINERY YOU LEARNT FOR YOUR MAIN JOB IN THE LAST 12 MONTHS, DID YOUR JOB TASKS CHANGE IN ANY OF THE FOLLOWING WAYS?

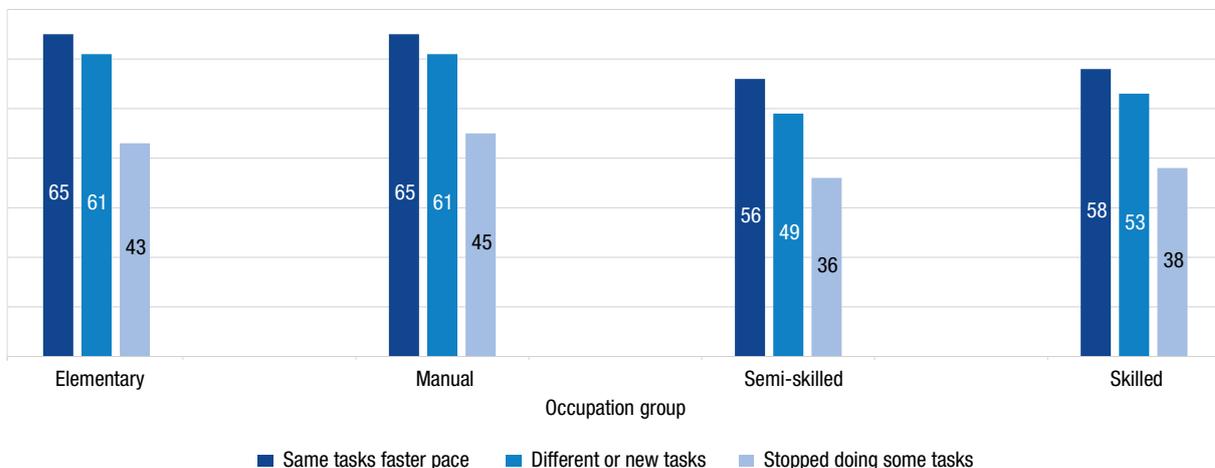


NB: The base is respondents who had to learn new computer software/programmes or computerised machinery in the last year (or since they started their job); weighted data.

Source: [Cedefop second European skills and jobs survey](#), 2021.

Figure 26. Change in job tasks due to digitalisation by occupational group, EU+, 2020-21

D\_CHJOB: AS A RESULT OF THE NEW COMPUTER PROGRAMMES OR SOFTWARE/NEW COMPUTERISED MACHINERY YOU LEARNT FOR YOUR MAIN JOB IN THE LAST 12 MONTHS, DID YOUR JOB TASKS CHANGE IN ANY OF THE FOLLOWING WAYS?



NB: The base is respondents who had to learn new computer software/programmes or computerised machinery in the last year (or since they started their job); weighted data.

Source: [Cedefop second European skills and jobs survey](#), 2021.

tasks faster than before, improving work efficiency.

The extent to which technological change leads to job task shifts varies widely between European countries (Figure 25). About half of Irish and Romanian workers experienced task replacement following the take-up of new digital technologies, compared to only 23% of Cypriot and 28% of Norwegian workers. Ireland, Romania and Poland (67%) are also countries where digital innovation

translates into new tasks in many jobs.

Considering that much of the RBTC literature emphasises that automation-driven job losses are stronger in the middle of the labour market (Autor, 2015), the ESJS2 insight that task replacement is prominent also at the lower levels of the job market (Figure 26) is an important finding. 45% of workers in manual occupations and 43% of those in elementary occupations experienced

some technology-induced task replacement, compared to 38% and 36% of workers in skilled or semi-skilled occupations, respectively. This pattern is also visible in education attainment levels. 48% of low-educated workers do not do some of their tasks following the introduction of new digital technology and this share is higher than for higher (38%) and medium-level educated (39%) workers.

The technology impact on manual and elementary occupations is even more visible in new tasks. 61% of workers in these occupational groups do some different or new tasks because digital technology was introduced; this is higher than the shares found among skilled (53%) and semi-skilled workers (49%). The dynamic generation and destruction of tasks – particularly at the lower end of the labour market – brings into question whether analyses suggesting that companies aim for job simplification to enable job outsourcing and automation (Schwab, 2016) still hold in today's labour market.

### 4.3. Tasks Europeans do in digital work

#### 4.3.1. Measuring skill demands using the task approach

The measurement of 'what gets done' at work is central to analyses on the nature of and returns on skills and work (Gittleman et al., 2016; Handel, 2016, 2020). However, few data sets contain information on job tasks, defined as 'a unit of work activity that produces output' (Autor, 2013), and most systematic attempts to capture tasks performed at work from an international perspective do not cover all EU Member States and are dated. Data scarcity has resulted in analyses of job content and skill demand relying on occupational or educational proxies, rather than data on actual tasks (Agasisti et al., 2021). Such approaches ignore the marked heterogeneity of tasks performed within occupations (Freeman et al., 2020; Fernandez-Macias and Bisello, 2022) or by workers with the same level of education, or commonalities between occupations and workers with different education levels (Autor, 2013).

Technological progress does not only entail a dynamic churning of tasks. Significant digital change in labour markets is likely to elevate the importance of some skills, rendering others less important or obsolete (Deming, 2017; Deming and Noray, 2020). A key novelty of the ESJS2 is that it obtained robust, harmonised measures of different job-skill requirements and of how these have recently changed (Box 5). This makes it possible to explore whether the adoption of new digital technologies in EU+ workplaces drives skills upgrading or downgrading in jobs.

The ESJS2 approach to measuring job-skill requirements in EU+ labour markets is based on factual questions that can be well-understood by individuals with different linguistic capabilities and across occupational contexts. This greatly improves the quality of skill demand measures in an international context (Handel, 2016). Combining job-skill requirements into a summary index makes it possible to characterise in broad terms the level of skill demand in European labour markets. The correlation of this index with the DSI index presented in Chapter 3 provides further insight into how digitalisation relates to skill demands in the European economy.

This section presents an analysis of regular tasks performed by EU+ workers, covering those focused on 'Data, People and Things' (Miller et al., 1980), which are also referred to as 'intellectual, social and physical tasks' (Fernández-Macías and Bisello, 2022). The ESJS2 measured the level of complexity of the literacy (reading and writing), numeracy (mathematical tasks), problem solving/creativity, interpersonal and physical tasks carried out regularly by adult workers. While discussions on the importance of literacy and numeracy (foundation skills) are long-standing, and physical tasks are usually considered to be in decline, recent research acknowledges the increasing importance of problem solving and interpersonal skills. This is partly because such skills are seen as shielding workers from automation (Spitz-Oener, 2006; Deming, 2017; Frank et al., 2019; Brown and Souto-Otero, 2020).

### Box 5. Measuring job-skill requirements

The skills required by jobs are diverse and multidimensional, and they can be specified in potentially infinite levels of detail. No survey or study can capture ‘all’ the skills involved in a particular job, because any description of what a job entails can always be enriched with further detail. There is also a tension between detail and comparability across occupations—very detailed measures tend to be occupation-specific, while overly general measures risk being only weakly informative.

For a long time, the economics literature treated job-skill requirements as a black box, without measuring them directly. Observing wage and employment increases at the higher end of the labour market, SBTC literature typically assumed that job skill requirements were rising rapidly in advanced economies. Broad occupation level (e.g. ISCO) and the average wage or education level per occupation group have been widely used as proxies of (changing) skill demand. Criticising such indirect approaches already quite early, Handel (2003) argued that ‘real progress on the question of skills mismatch requires development of a new, validated, standardized method of measuring job skill demands administered consistently to representative samples of workers over time to understand exactly in what ways work is changing’.

Eventually, the literature embraced direct job-skill requirements measurement, using the US *Dictionary of occupational titles* (DOT) and its successor, the Occupational information network (O\*NET). In the past two decades the use of direct skill measures has burgeoned and there is now a growing number of studies using and further developing them (Spitz-Oener, 2006; Green, 2012; Handel, 2016; Deming, 2017).

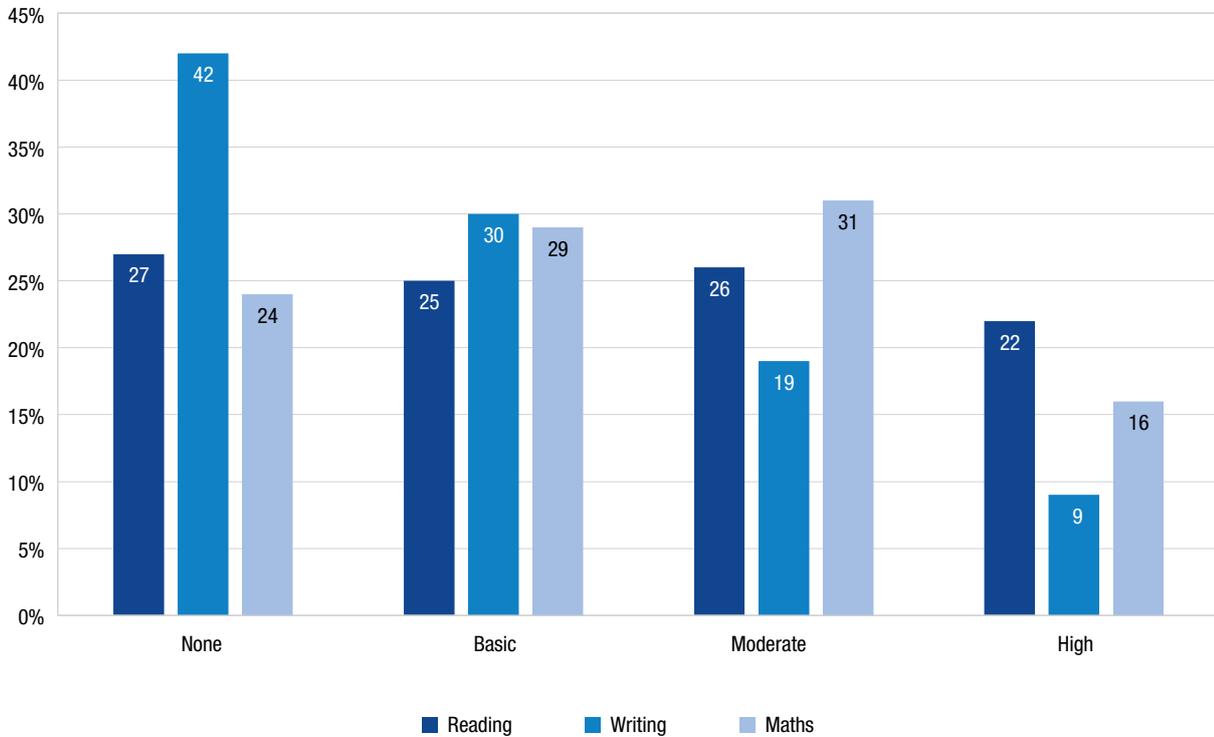
The U.S. STAMP survey is a notable example of a task-based approach to measuring skill requirements using explicit scales (Handel, 2017). It collected information on the level of education and the levels of reading, writing, maths, problem-solving and interpersonal skills required by jobs, and the use of computer applications (Handel, 2016). The main value added of the task-based measurement approach in STAMP is its attempt to infer transversal skills and a reasonably concise list of specific requirements (e.g. digital activities) directly from job holders. This makes it possible to develop generalised measures across occupations. STAMP inspired the job-requirements module developed for the OECD’s PIAAC survey.

Building on STAMP’s approach of measuring skill demands by focusing on workers’ engagement with ‘data, people, and things’, and guided by the European task framework (Fernandez-Macias et al., 2016; Bisello et al., 2021), the ESJS2 measures the intensity of cognitive, interpersonal and manual skills required in jobs. The item batteries on job-skill requirements are not lengthy or onerous to administer and permit comparisons and benchmarking across countries. Using the task approach is a notable improvement compared to asking workers to assess the ‘importance’ of a set of skills for their jobs, the approach used in the first ESJS.

Extracting skills from online job postings also offers a rich source of information on job-skill requirements that will be increasingly important in research going forward (Cedefop, 2021b; Cedefop et al., 2021). At the same time algorithmic approaches to uncovering skill needs from big data have significant limitations in terms of representativeness, coverage and conceptual validity (Sostero and Fernandez-Macias, 2021); it will not eliminate the need for surveys designed to measure skill needs. Well-designed skills surveys ensure that skills information is collected in a harmonised and comparative manner, while also uncovering statistical associations between economic and social variables (Cedefop, 2021a).

Figure 27. **Foundation job-skill requirements, EU+ jobs, 2021**

**C\_READ/WRITE/MATHS: AS PART OF YOUR MAIN JOB, DID YOU DO THE FOLLOWING ACTIVITY IN THE LAST MONTH?**



NB: Basic reading requirements correspond to jobs in which workers read texts, on paper or computer screens that are 1-4 pages long; moderate reading is 5-24 pages long; high reading refers to texts that are at least 25 pages or longer. Writing requirements correspond to jobs in which workers write texts that are either at a basic level (1-4 pages), moderate level (5-24 pages) or high level (more than 25 pages). Basic maths requirements imply that workers have to perform simple calculations with numbers (adding, subtracting, multiplying or dividing) regularly as part of their job, whether on their own or with the help of a computer or calculator. Moderate mathematics requirements refer to jobs that require the use of simple algebra or mathematical formulas (for instance, calculating fractions or percentages or trying to find an unknown quantity). High maths refers to the use of any kind of more advanced mathematics, algebra or statistics, for instance calculus, regressions or simulation analysis.

Source: Cedefop second European skills and jobs survey, 2021.

#### 4.3.2. Foundation (literacy and numeracy) skills

Most European workers need foundation skills to do their work (Figure 27). More than three quarters of adult employees carry out tasks that require some reading and numeracy skills and close to half of them need above-basic levels of proficiency. 31% use simple algebra or mathematical formulas and 16% more advanced mathematics, algebra, or statistics. 22% read documents that exceed 25 pages as part of their main job. 58% of EU+ workers undertake some writing tasks (i.e. write text of at least one page long); most of them (30%) do so at a relatively basic level (writing text of maximum five pages).

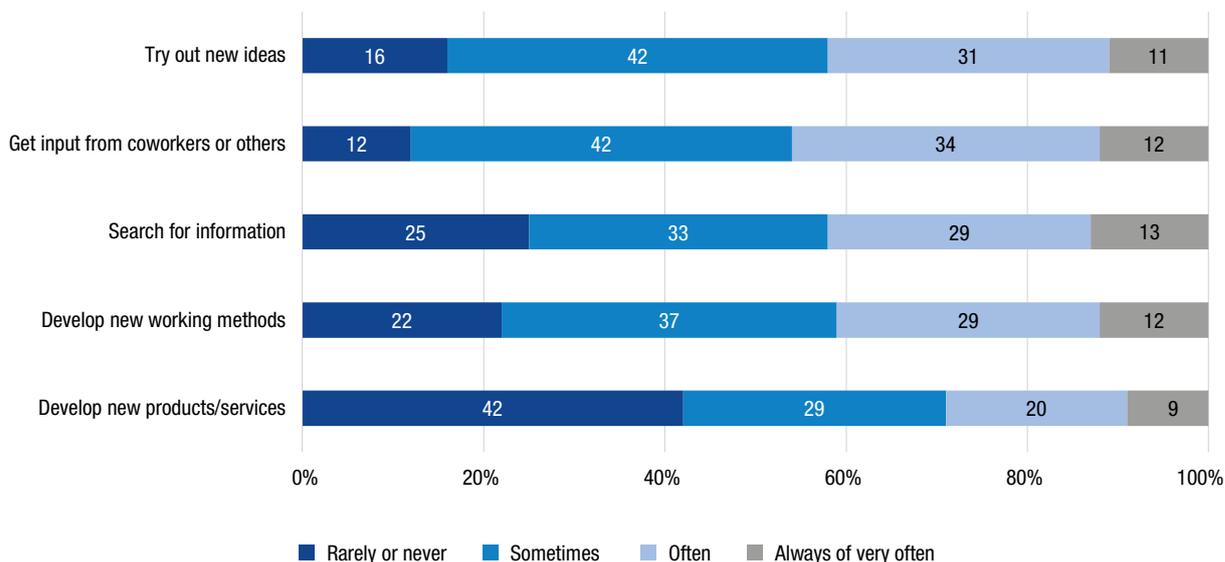
Similar to Handel (2016) reporting for the USA, there is a long tail of low-skilled jobs in EU+ job markets. About one in four EU+ workers do not

need to read (27%) or undertake even simple calculations (24%) at work at all, or usually read less than five pages (25%). This should be a cause of concern given that those with few or no opportunities to use foundation skills at work are more likely to see them depreciate and do not develop them, compounding the large basic skills deficits from early education observed in many developed countries (Cherry and Vignoles, 2020).

Skill demands vary considerably across countries and occupations. Almost nine in 10 (87%) adult workers in Finland (the highest share) perform numerical tasks in their jobs, while seven in 10 (69%) do so in Italy (the lowest share). The use of at least some numeracy skills to perform job tasks is particularly high in east European countries (e.g. 85% in Slovenia, 84% in Hungary and Romania). More than one in three workers in Italy,

Figure 28. **Problem-solving and creativity skill requirements, EU+ jobs, 2021**

C\_PRB\*: HOW OFTEN DID YOU DO ANY OF THE FOLLOWING ACTIVITIES AS PART OF YOUR MAIN JOB IN THE LAST MONTH?



NB: The first three problem solving tasks were asked only in the ESJS2 online sample. The last two tasks were addressed to all respondents.  
 Source: Cedefop second European skills and jobs survey, 2021.

Cyprus, France, Lithuania and Bulgaria usually read less than one page in their job or do not have to read at all.

Workers in skilled occupations are about five times more likely to read long documents (over 25 pages) than those in elementary occupations (32% versus 7%). Three in four workers (73%) in elementary occupations write texts shorter than one page or do not write any text at all. This is significantly higher than the approximately two thirds (64%) of workers in manual occupations, half of those in semi-skilled occupations (47%) and one in four adult employees in skilled occupations (26%). Workers in skilled occupations use advanced maths three times more often than workers in elementary occupations (22% versus 7%), and twice as much as those in semi-skilled occupations (11%). While only 17% of workers in skilled occupations do not use any maths, this is the case for almost half (45%) of those in elementary occupations.

#### 4.3.3. Problem-solving skills and creativity

Despite increasing emphasis on the importance of problem solving as a shield against automation, frequent problem solving is relatively rare

when compared to other intellectual tasks such as reading, writing and maths and interpersonal skills (see also OECD, 2013). Aiming to map the extent to which EU+ jobs rely on problem-solving and creativity skills, the ESJS2 asked adult workers how often, in the last month preceding the survey, they

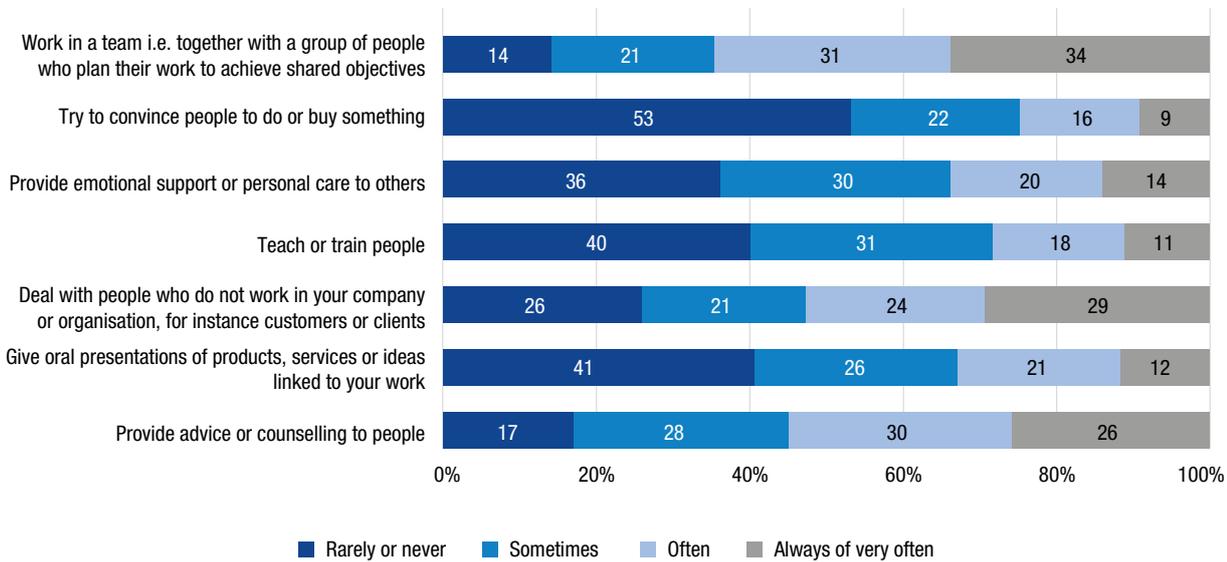
- searched for relevant information or documentation, for instance in books or on the web, to solve problems;
- got input from colleagues or others to solve problems;
- tried out new ideas to solve problems;
- tried to develop or create new or improved products or services;
- tried to develop new or improved ways of doing their work <sup>(11)</sup>.

The analysis shows that the share of EU+ jobs that require employees regularly to solve problems or be creative is relatively small (Figure 28). Only about one in 10 EU+ adult workers always or very often solve problems or carry out innovative tasks in their job. Over half of them use their problem-solving capacity sometimes, at most, and even more do not regularly contribute to product (71%) or process innovation (59%).

<sup>(11)</sup> Items (a) to (c) were only asked to the online sample of the ESJS2, while (d) and (e) were addressed to the full (telephone and online) sample.

Figure 29. **Interpersonal job-skill requirements, EU+ jobs, 2021**

**C\_COM\***: HOW OFTEN DID YOU DO ANY OF THE FOLLOWING ACTIVITIES AS PART OF YOUR MAIN JOB IN THE LAST MONTH?



Source: Cedefop second European skills and jobs survey, 2021.

#### 4.3.4. Interpersonal/social skills

Interpersonal tasks and social skills are often seen as growing in importance in modern labour markets and are considered to protect workers against machine replacement (Deming, 2017; Pouliakas, 2018). They also complement intellectual tasks in many jobs (Eurofound, 2016). Measuring interpersonal job tasks is conceptually challenging because such tasks refer to qualitatively disparate behaviours (e.g. communicating with others, negotiating, persuading, selling, influencing, teaching, caring, counselling) that cannot easily be summarised using a skills complexity scale. Attempts to evaluate their incidence in surveys sometimes confound attitudinal and motivational work orientation dimensions (Moss and Tilly, 2001). An example is expressed willingness of workers to collaborate with colleagues, which may inflate the actual prevalence of teamworking in organisations.

Building on the approach used in the STAMP survey (Handel, 2016) and the conceptual framework underpinning the European tasks database (Bisello et al., 2021), the ESJS2 asked EU+ workers how often they do the following activities as part of their main job:

- (a) provide advice or counselling to people;
- (b) present products, services or ideas linked to their work;
- (c) deal with people who do not work in their com-

pany or organisation, for instance customers or clients;

- (d) teach or train people;
- (e) provide emotional support or personal care to others;
- (f) try to convince people to do or buy something;
- (g) work in a team i.e. together with a group of people who plan their work to achieve shared objectives.

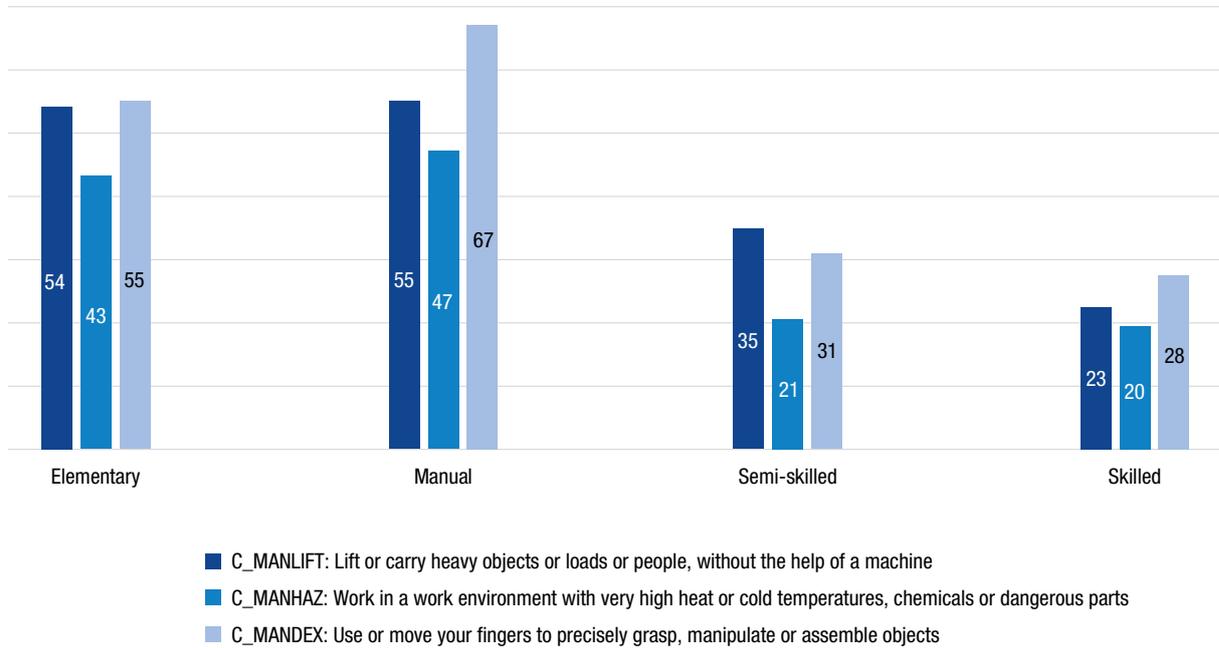
It appears that, at a time of unprecedented COVID-19 social distancing practices, which severely limited possibilities to work with and interact physically with others, the demand for social skills remained high (Figure 29). 59% of workers always or very often performed at least one of the seven social tasks mentioned above. Over eight in 10 adults worked as part of a team in their organisation and 74% dealt with outsiders such as clients or customers, at least sometimes, as part of their main job. A significant share of the EU+ workforce carries out interpersonal tasks which are relatively specific to occupations, such as selling, caring, or teaching.

#### 4.3.5. Physical/manual skills

The measurement of manual job-skill requirements has been neglected in recent research and analysis, even though the prevalence of simple manual labour is a strong indicator of national economic

Figure 30. **Physical job-skill requirements by occupational group, EU+ jobs, 2021**

C\_MAN\*: DID YOU DO ANY OF THE FOLLOWING ACTIVITIES AS PART OF YOUR MAIN JOB IN THE LAST MONTH?



NB: The question on manual dexterity (C\_MANDEX) is only asked in the online sample.  
 Source: [Cedefop second European skills and jobs survey, 2021](#).

development. Ensuring adequate supply of workers in skilled blue-collar trades is a constant challenge for nearly all economies, especially because replacement demand at this skill level is the lion's share of overall skill demand (Cedefop forecast, 2018).

Sometimes low prevalence of manual tasks is considered a signal of job quality. There is, for example, evidence of work councils in Germany supporting digital technology adoption in workplaces that employ a high share of workers conducting physically demanding tasks (Genz et al., 2019). Physically demanding job tasks have been linked to exit from the workforce (Weaver, 2020) and are negatively associated with the use of intellectual skills (Eurofound, 2016). Demand for physical tasks is typically inversely linked to progress in automation, since more advanced machines make it possible to let technology take over physically demanding tasks in occupations (Handel, 2020; Pouliakas, 2021).

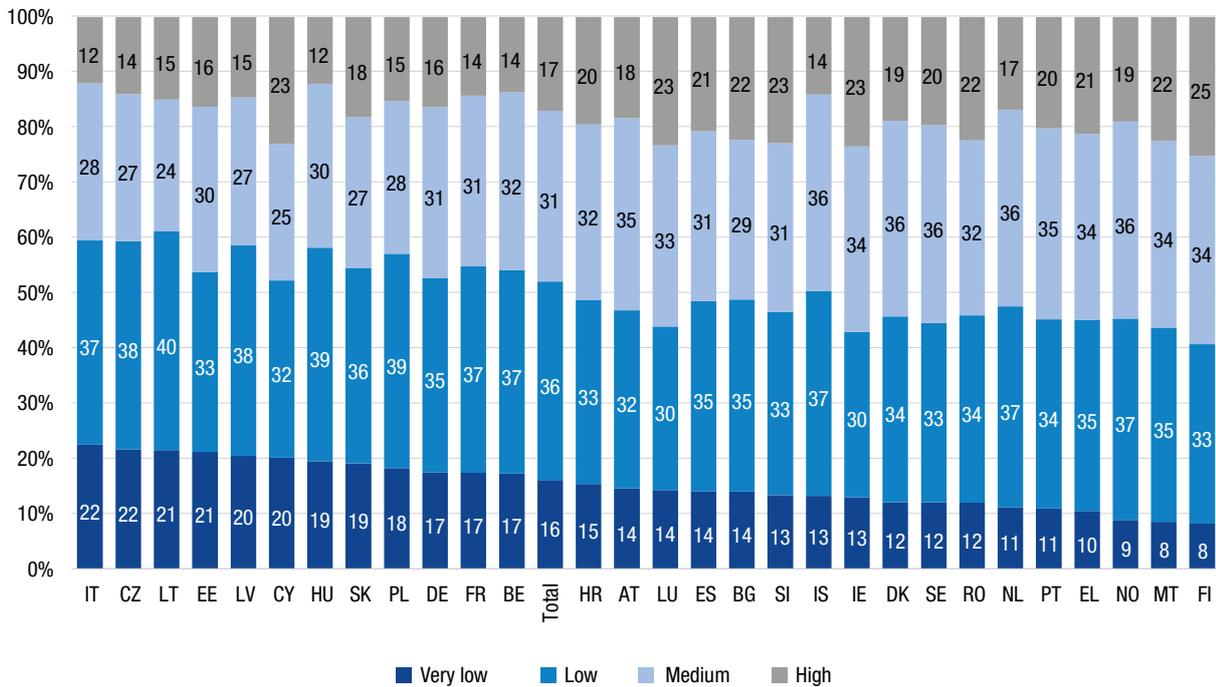
Following the STAMP approach, ESJS2 distinguishes between simple and more complex physical tasks. Simple manual tasks include gross physical exertion: lifting and carrying heavy loads

or people without the help of a machine, and activities typically done in dangerous or unhealthy work environments (e.g. exposure to heat or cold or chemicals and other hazardous materials).

Tasks such as adjusting technical parameters and controls of machines or operating them, while more complex than simple physical tasks, require less knowledge and skills compared to the tasks of those who must maintain or repair them, or write or modify computer programmes to run them. Other physical tasks such as using or moving one's hands or fingers to grasp, manipulate or assemble objects (excluding working with a mouse, typing on a keyboard or handwriting) signal manual dexterity required in jobs.

While manual skills may be decreasing in importance (Eurofound, 2018), they remain widespread in Europe (Figure 30). One in three EU+ workers (35%) carry heavy objects or loads at work (over half in manual and elementary occupations). One in four (27%) works in an uncomfortable or hazardous work environment, while about 38% (67% in manual jobs) use their hands to manipulate objects. 18% of adult workers in the EU+ have a job with very high physical strain,

Figure 31. Job-skill requirements across EU+ countries, 2021



NB: See Annex 3 for details of the methodology of index derivation.  
 Source: Cedefop second European skills and jobs survey, 2021.

because they must lift heavy objects while also working in an uncomfortable or dangerous work environment.

Providing additional insight into the type of manual labour demanded, ESJS2 analysis shows that 39% of EU+ adult employees use at least one of the computerised machines described in Chapter 3 (digital handheld devices, CNC machine tools, robots, PLCs etc.) as part of their main job; 1 in 5 workers (20%) operate these machines as part of their work and 12-13% set their technical parameters or maintain and repair them. At the higher end of the skills spectrum, 8% write computer programmes or code for them <sup>(12)</sup>.

#### 4.3.6. Linking skill demand to digitalisation

A composite ESJS2 skill demand indicator summarises the level of job-skill requirements in EU+ labour markets, by compiling information on literacy, numeracy, problem-solving and interpersonal job-skill requirements, described above (see Annex 3 for methodological details).

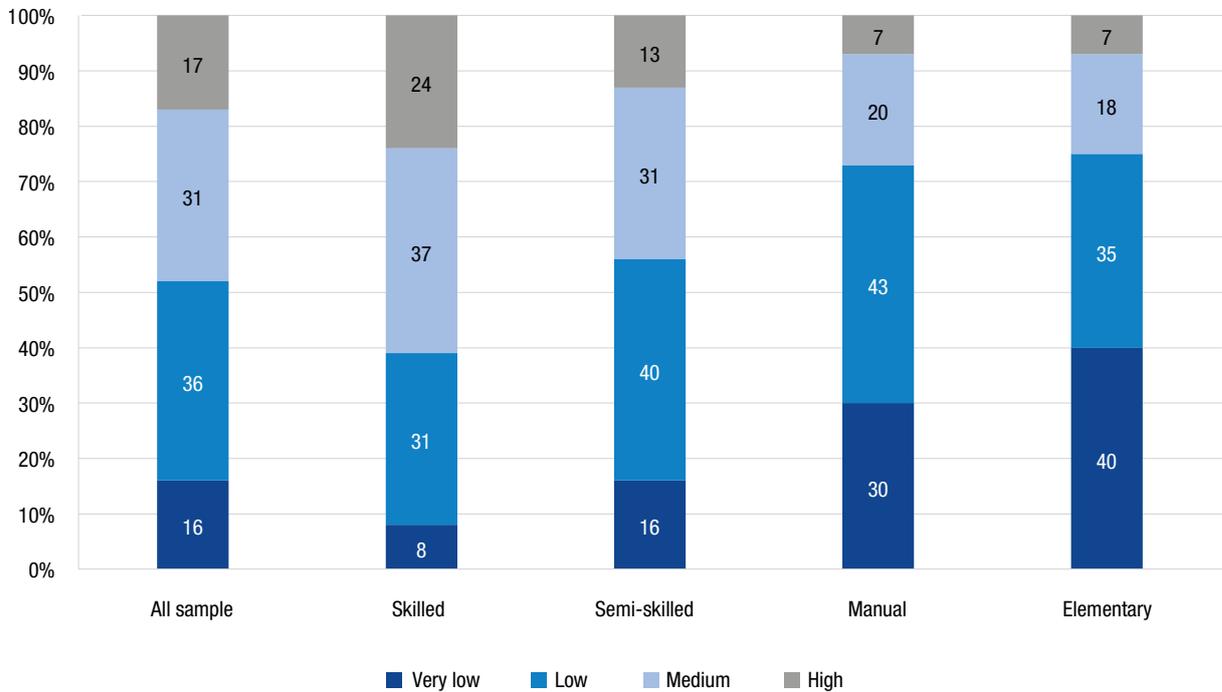
Mirroring the distribution of its components, the index shows that over a half (52%) of all jobs

in EU+ labour markets have relatively low skill demands with 16% at very low level. 31% of workers are in jobs with moderate job-skill requirements – tantamount to them carrying out their job tasks often or at a medium difficulty level – and 17% require a high skill level. A relatively high share of employed adults in Finland (25%), Ireland, Luxembourg, Cyprus, and Slovenia (all at 23%) is in jobs with high skill demands. This contrasts with countries where, comparatively, many workers are in jobs with very low skill requirements, such as Italy (22%), Czechia (22%) and the Baltic states (20-21%).

The job-skill requirements index is well-defined across the different occupational groups, with over seven in 10 jobs being at best low-skilled in manual and elementary occupations (Figure 32). By contrast, 61% of employment in skilled occupations requires above medium skill levels. There is considerable variation in job-skill requirements within occupational groups, with low- and high-skill intensive jobs found across the board. For instance, one in four jobs in elementary occupations requires a very high skill level, while

<sup>(12)</sup> The ESJS2 questions on the use of computerised machines were only asked in the online component of the survey.

Figure 32. Job-skill requirements by occupational group, EU+, 2021



Source: Cedefop second European skills and jobs survey, 2021.

about four in 10 (39%) in skilled occupations are of low skill level at most. This demonstrates that the often used ‘skilled versus non-skilled’ distinction based on occupational classifications (such as ISCO) may overgeneralise skills patterns and blur the true nature of skill demand in European labour markets.

Considering such variation in skill demands, it is obvious that jobs with higher overall job-skill requirements tend to be more ‘digital’ (Figure 33). The strong positive correlation between digital intensity jobs and skill demands is also evident from the finding that 72% of jobs relying on advanced digital technologies (e.g. programming or ICT system maintenance) need at least moderate skills. Jobs in which workers undertake mostly basic digital activities (e.g. browsing the web, word-processing) are dominated by tasks demanding low skills (62%). A vast majority of jobs not relying on digital technology only requires a low or very low skills level (87%).

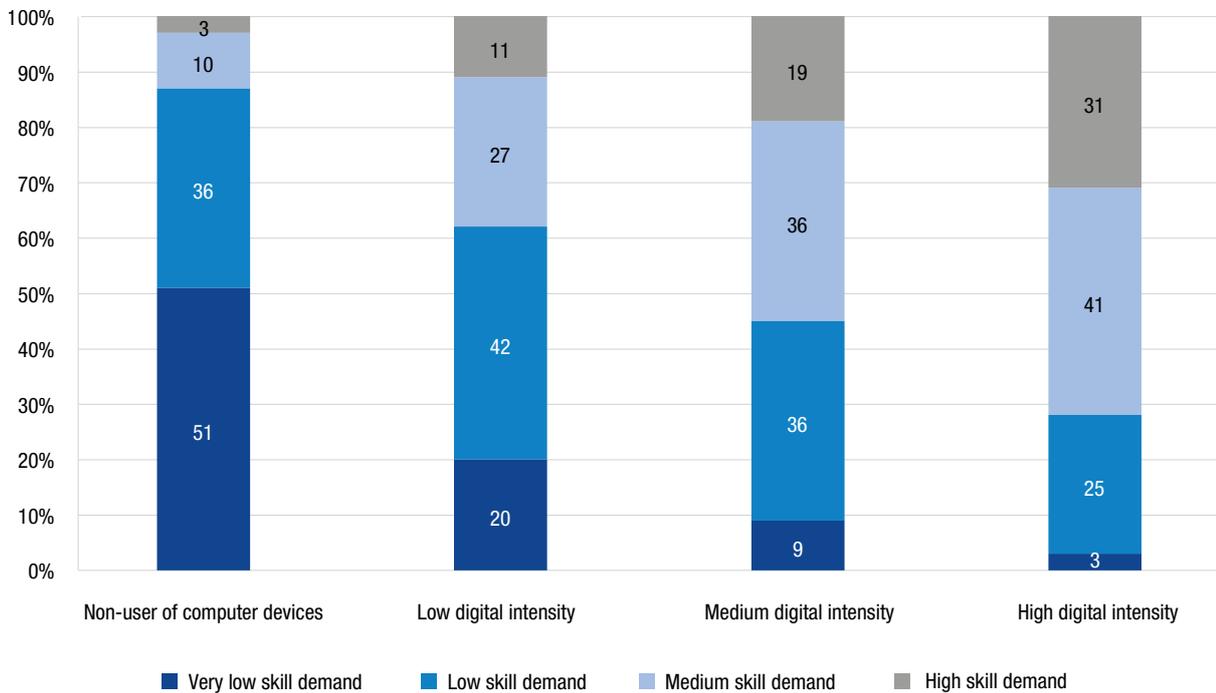
## 4.4. Digitalisation and job routinisation

### 4.4.1. Measuring work routinisation and job complexity

The way in which digital technologies affect the nature of work is a central, and at times fiercely discussed, theme in the future of work debate. The complementarity thesis puts forward the idea that, in the long run, digitalisation will reduce routine work and enhance job quality, allowing workers to focus on more interesting, rewarding and complex tasks (Bessen, 2015, 2016; Autor, 2015; Menon et al., 2020). The notion that part of routine work displacement occurs because of automation in routine intensive occupations – typically those at medium-skilled level – is the core of the RBTC hypothesis. An alternative view is ‘Digital Taylorism’, which predicts that adopting technology will make work more routine and de-skilled (Brown et al., 2010; Chang, 2010) with negative impacts on job satisfaction <sup>(13)</sup>.

<sup>(13)</sup> Apart from directly reducing job satisfaction, workers may also become less satisfied with their job because of increasing use of algorithmic management and employee surveillance (Kellogg et al., 2020; Baiocco et al., 2022).

Figure 33. Job-skill requirements by DSI, 2021



Source: Cedefop second European skills and jobs survey, 2021.

A positive association between new digital technologies and the routine intensity of occupations may, therefore, be expected (inter-occupation effect). But it is not clear *a priori* if digitalisation is linked to more or less work routinisation for employees who have ‘survived’ routine-biased technological automation (intra-occupation effect). The type of digital technology may determine how different types of workers are affected by it, for instance skilled versus production workers (Milkman and Pullman, 1991).

Much of the RBTC/job polarisation literature views ‘routine’ tasks as rule-based activities which are relatively easy to codify and automate by programming their functionality using machines (Spitz-Oener, 2006). A technology-driven definition of routine jobs is unfortunate and problematic, as it may deviate from what workers perceive as routine work (Green, 2012; Matthes et al., 2014). Before automation became a major concern in discussions on jobs and skills, routine jobs were mostly defined in terms of their characteristics – low-skilled, uninteresting, and generally monotonous

or repetitive – and not restricted to middle-skilled jobs with codifiable tasks<sup>(14)</sup>. Weak conceptual clarity and lacking accepted operational measures of work routinisation have contributed to confusion in the literature. From research on job routinisation, it is obvious that how routineness is measured matters in interpreting findings (Sebastian and Biagi, 2018).

To overcome these weaknesses, the ESJS2 conceptualises the degree of routinisation at work using two dimensions:

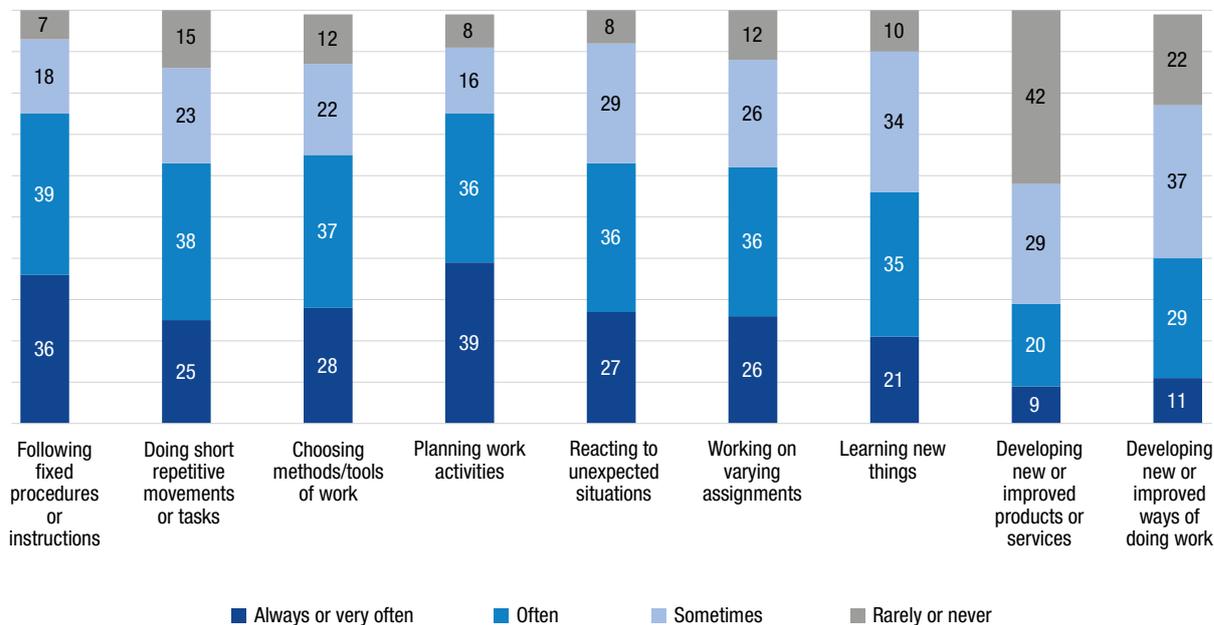
- (a) the extent to which jobs are subject to fixed procedures and standardised work routines, along with the intensity of their task repetitiveness;
- (b) a job’s complexity, defined in terms of whether work is organised in a way that provides employees with scope for autonomy or requires breadth and depth of learning and generalised creativity and problem-solving capacities.

The definition of routine work provided by the European task framework (‘a sequence of actions carried out regularly and identically’) (see Fernan-

<sup>(14)</sup> RBTC for example considers the job of a travel agent ‘routine’ because determining the best itinerary for a trip at the lowest price is easily programmed using information technology, while it views the jobs of office cleaners, drivers and retail store shelf-stockers as ‘non-routine’ because the irregular physical layout of their work environment makes task automation difficult.

Figure 34. **Work routinisation and job complexity, EU+, 2021**

**B\_RT:** HOW OFTEN DOES YOUR MAIN JOB INVOLVE THE FOLLOWING ACTIVITIES? / **C\_CREA\*:** HOW OFTEN DID YOU DO THE FOLLOWING ACTIVITIES AS PART OF YOUR MAIN JOB IN THE LAST MONTH?



Source: Cedefop second European skills and jobs survey, 2021.

dez-Macias and Hurley, 2017; Bisello et al., 2021) was used to construct a routinisation index. The distinction this framework makes between the repetitiveness and standardisation of tasks is mirrored in the ESJS2 analysis by considering the frequencies of ‘short, repetitive movement or tasks’ and ‘fixed procedures or instructions’ in jobs.

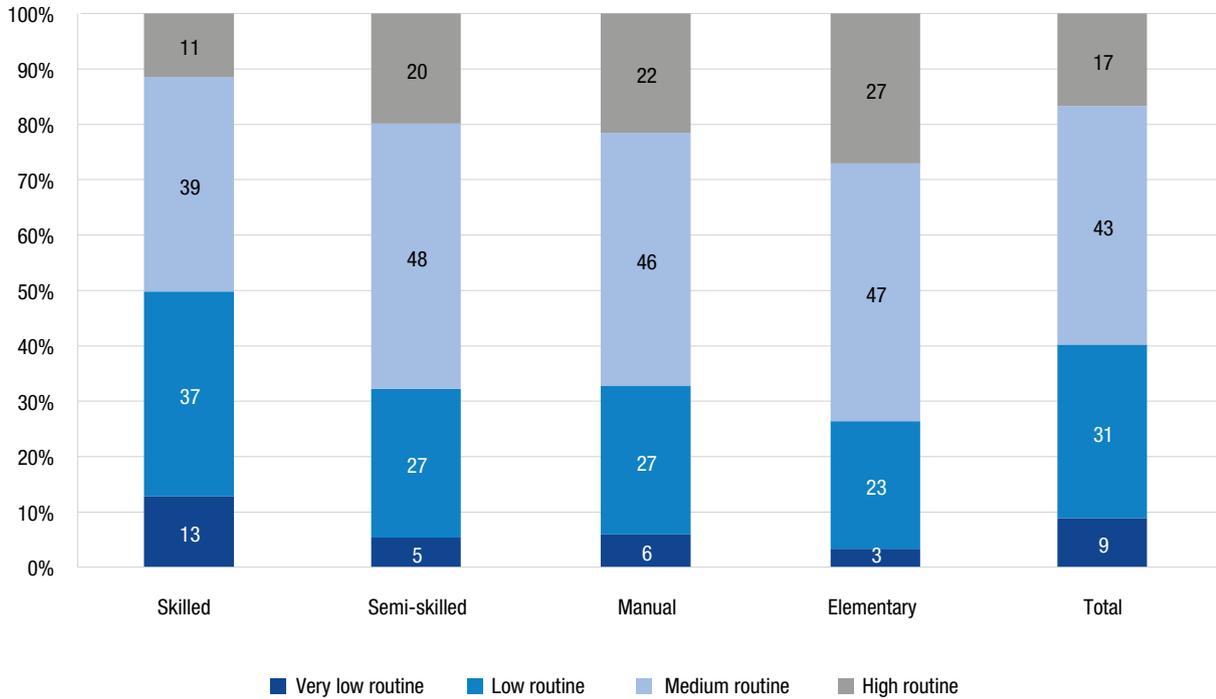
Job complexity and the ESJS2 composite index measuring it consider the extent to which workers can ‘choose the methods or tools of their work’, ‘plan their work activities’, ‘react to situations that could not be anticipated’, ‘work on varying assignments’, ‘learn new things’, ‘try to develop or create new improved products or services’ and ‘try to develop new improved ways of doing their work’ (Autor et al., 2003; Autor and Handel, 2013, Green et al., 2013; Oldham and Cummings, 2017).

Bisello et al., (2019) signalled that while the employment share of ‘routine jobs’ in the EU is shrinking, routinisation within jobs is increasing. Routine work and task discretion or autonomy coexist in many European jobs (Figure 34). Around 75% of EU+ workers frequently follow fixed procedures or instructions and for 63% work tasks are highly repetitive. At the same time, most workers report

high autonomy, problem-solving and learning. A majority benefits from often or always being able to plan their work activities (75%) or from choosing work methods or tools (65%). For six in 10 workers, reacting to situations that could not be anticipated is usual (63%), as is high task variety (62%). More than half (56%) learn new things at work. ESJS2 analysis suggests that work routinisation – in terms of repetitiveness of tasks and fixed procedures – does not necessarily preclude autonomy and skill development opportunities.

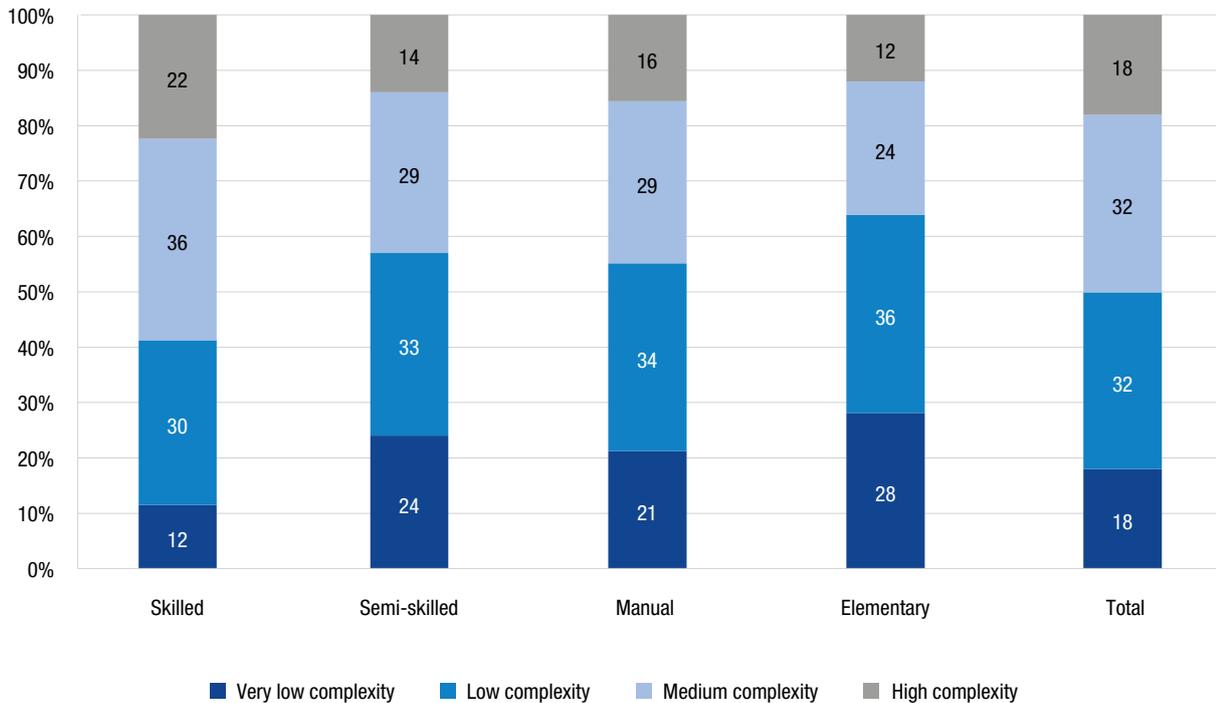
Over half of all jobs in Europe are relatively repetitive and standardised. The ESJS2 routine-ness index shows six in 10 jobs in Europe can be characterised as routine, with 17% having a very high routine task intensity (Figure 35). It is 27% for employees in elementary occupations and 24% for low-educated workers. In contrast, only one in 10 skilled occupation workers, and only 12% of those with high education, need to follow predefined rules and do repetitive tasks. Adult workers in Cyprus, Bulgaria, Greece, Romania and Slovakia are more likely to be in high routine jobs compared to their counterparts in other European countries. In Sweden, Netherlands, Denmark and Luxembourg, the share of highly routine jobs is relatively low.

Figure 35. Routine task intensity by occupational group, EU+, 2021



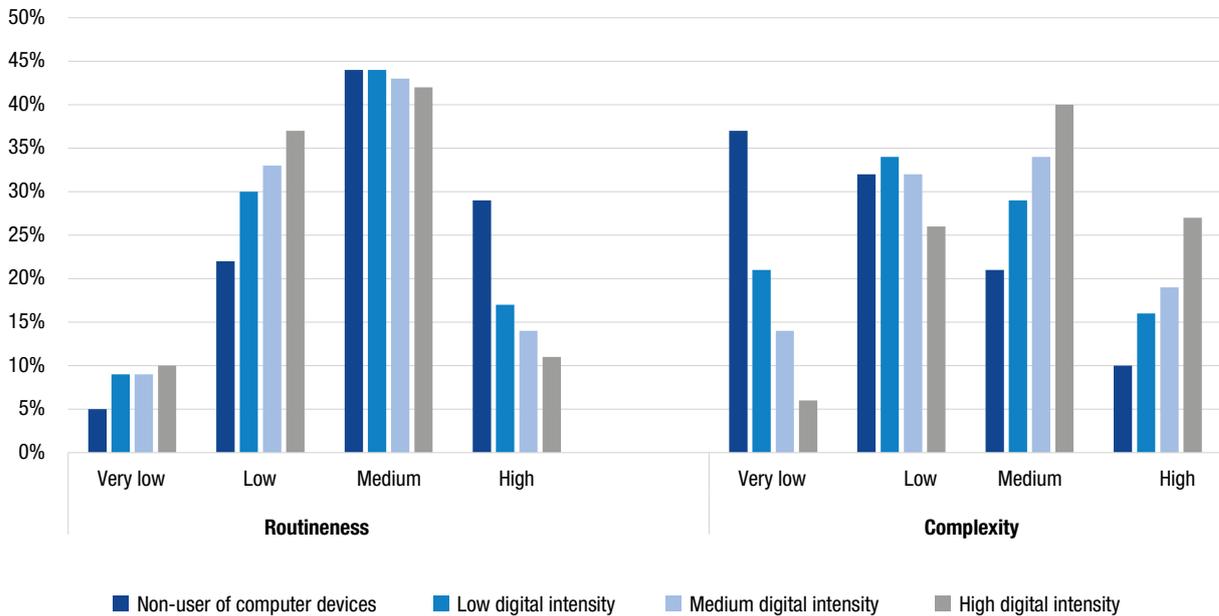
NB: See Annex 3 for details of the methodology of index derivation.  
 Source: Cedefop second European skills and jobs survey, 2021.

Figure 36. Job complexity by occupational group, EU+, 2021



NB: See Annex 3 for details of the methodology of index derivation.  
 Source: Cedefop second European skills and jobs survey, 2021.

Figure 37. DSI, work routinisation and job complexity, EU+, 2021



Source: Cedefop second European skills and jobs survey, 2021.

Five in 10 EU+ workers are in jobs of low complexity, two of which (18%) hold a job with very low complexity (Figure 36). In such jobs adults have little or no discretion in carrying out their job tasks and limited or no learning opportunities. While jobs belonging to more skilled occupational groups tend to be more complex, the share of non-complex jobs in the skilled (12%) and semi-skilled (24%) categories is significant. Challenging conventional beliefs, a large share of manual workers (16%) has a relatively high degree of task discretion and creativity at work, comparable to the job conditions of employees in semi-skilled occupations.

#### 4.4.2. Digital technology and work routinisation

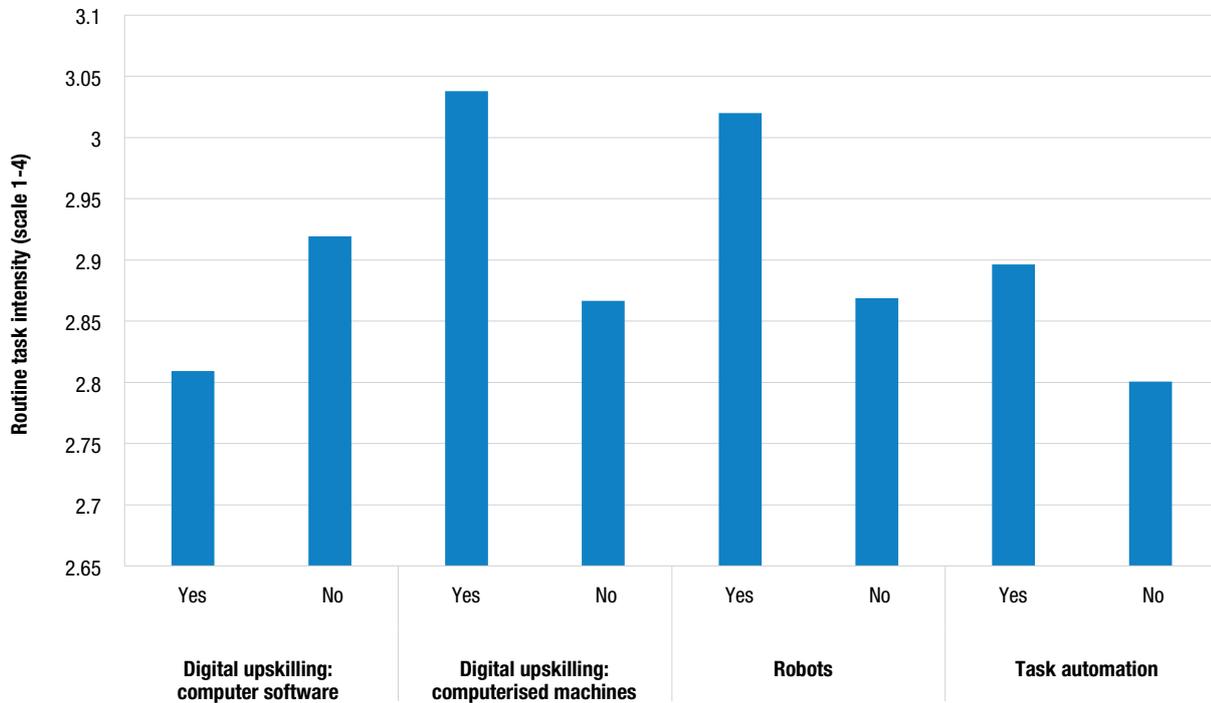
ESJS2 analysis sheds light on the complex relationship between digitalisation, work routinisation and job complexity. It shows the digital intensity of jobs and the degree of task routineness are inversely related, and a positive link between digital intensity and job complexity (Figure 37). Digital jobs are less likely to be routine jobs, and typically have higher autonomy and more skill development opportunities.

The links between digital intensity, routinisation

and job complexity established via empirical analysis point towards digitalisation going hand-in-hand with job quality. It is important to acknowledge at the outset that average cross-sectional correlation may also reflect industrial or occupational composition effects, or other demographic and job characteristics of adult workers. For instance, DSI and job complexity could be positively related as they are both prominent features of more skilled occupations. Correlations possibly also blur underlying dynamic effects. The ESJS2 contains information only on jobs that have not been automated. Routine-intensive jobs automated in the past are not present in the sample. 'Surviving' jobs may have, in contrast, already undergone the dynamic task reallocation effects described in Section 4.2. This would explain why jobs with adopted digital technologies have fewer routine and more autonomous tasks.

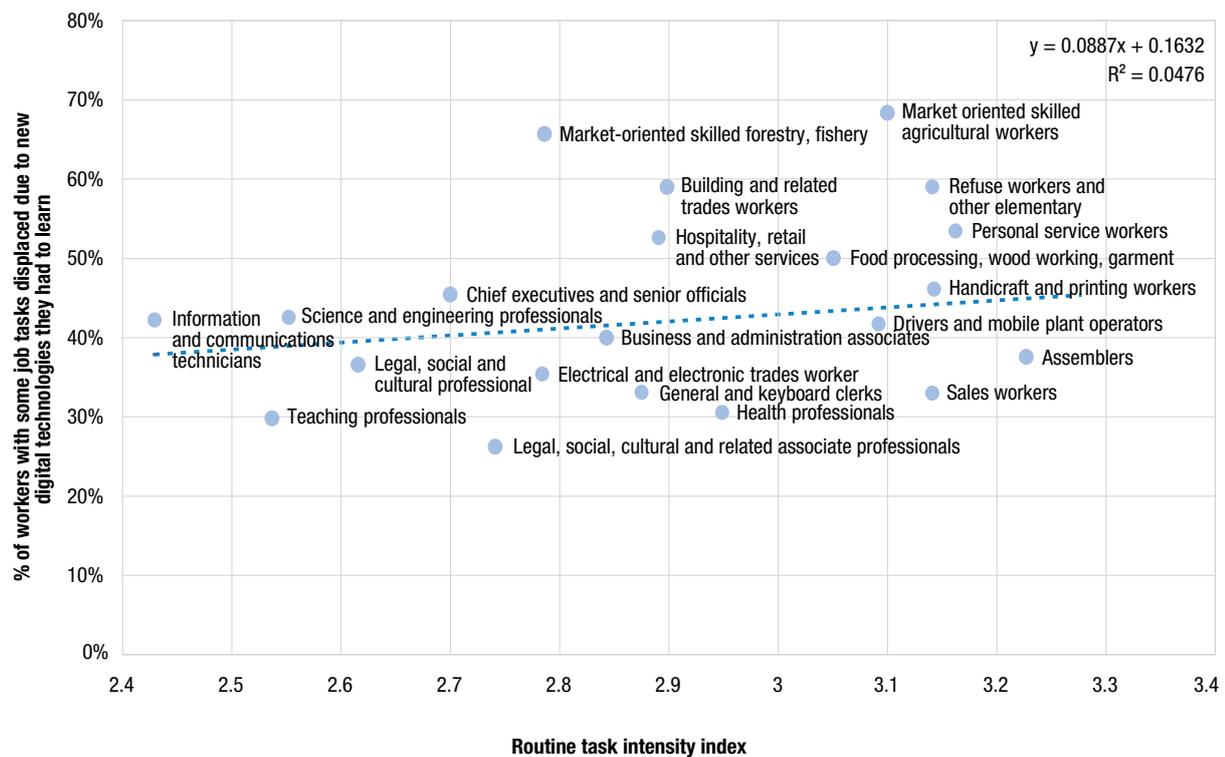
Menon et al. (2020) suggest the autonomy-enhancing effect of technology may be stronger for workers in cognitive occupations and with higher levels of education, while their standardisation effect may be more pronounced in manual occupations. Alongside considering such potentially diverse occupational effects, acknowledging that diverse digital technologies may have different

Figure 38. Automating digital technology and work routinisation, EU+, 2021



Source: Cedefop second European skills and jobs survey, 2021.

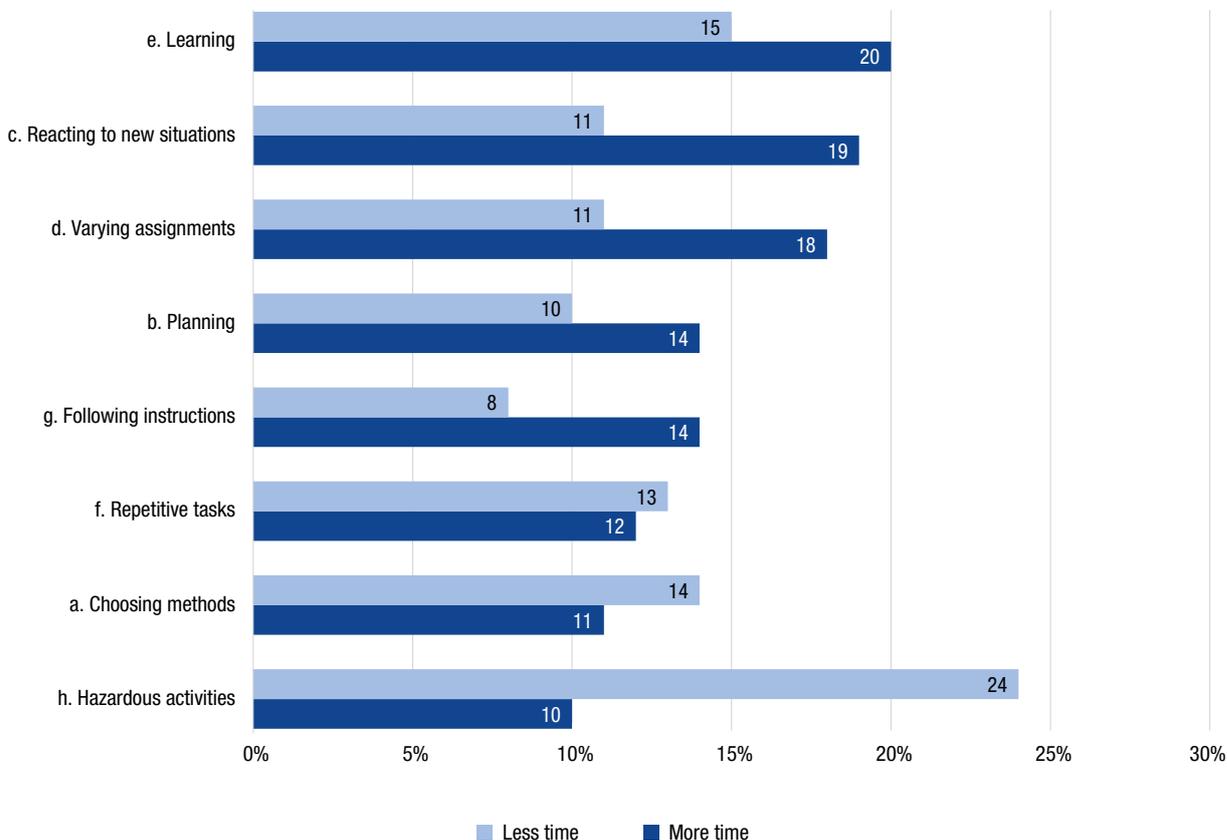
Figure 39. Task automation and work routinisation, EU+, 2021



Source: Cedefop second European skills and jobs survey, 2021.

Figure 40. **Changing job routinisation and complexity, EU+, 2020-21**

**C\_CHWK:** IN YOUR MAIN JOB, DO YOU NOW SPEND MORE TIME, ABOUT THE SAME TIME OR LESS TIME ON THE FOLLOWING ACTIVITIES COMPARED TO 12 MONTHS AGO/WHEN YOU STARTED IT? ITEMS REFLECTING DIFFERENT ACTIVITIES



NB: All respondents for items a, f, e. Only online sample for items b,c,d,g,h.  
Source: Cedefop second European skills and jobs survey, 2021.

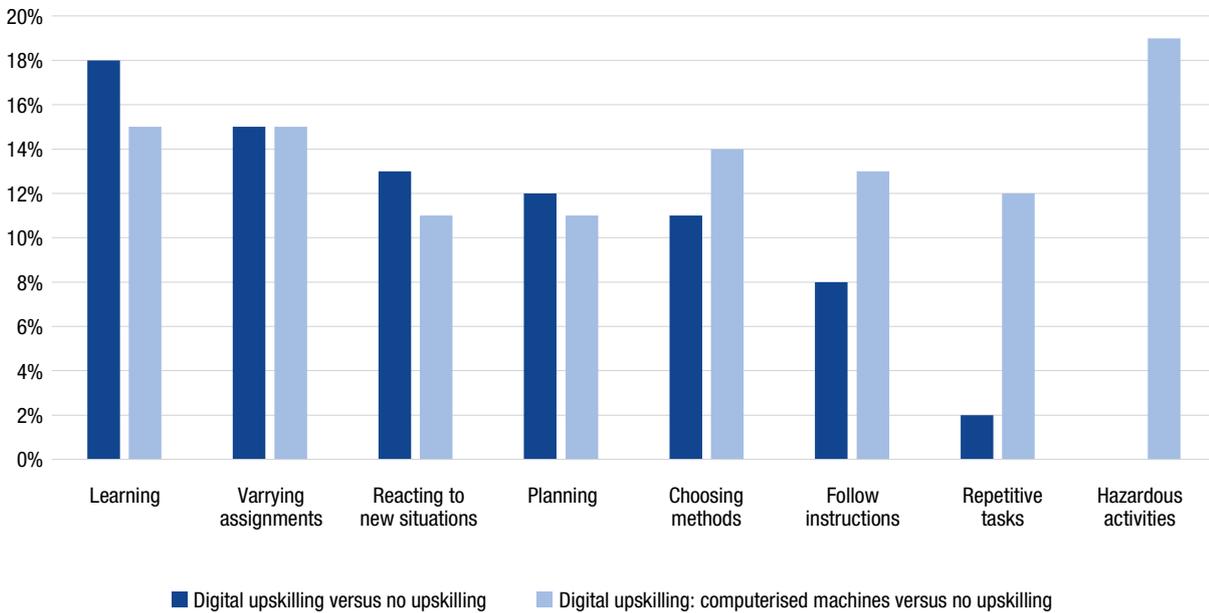
labour market outcomes is important (Fosen and Sorgner, 2022).

The type of digital technology introduced determines its effect on the routineness of jobs (Figure 38). The jobs of workers who had to learn to use new computer software between 2020-21 are, on average, less routine than those who were unaffected by it. For newly adopted computerised machines and particularly robots – technology which typically automates job tasks – the link with work routinisation is positive. Workers in jobs with more routine tasks are more likely to have experienced some task destruction following the adoption of new digital technologies, confirming the RBTC hypothesis. Agricultural and refuse workers (i.e. working with garbage or waste), those in hospitality or personal services, handicraft and printing, food processing and stationary plant and machine operators are some examples of high routine occupations where one in two workers

saw some of their tasks destroyed by new digital technology (Figure 39).

The positive and significant relationship between task automation and job routineness holds when accounting for differences in demographic and job characteristics (including industrial and occupational effects and job task complexity) between workers learning new digital technologies and those who did not (Table 2, Section 3.5). The use of digital machines is positively associated with routine work, primarily in manual occupations but also in skilled professions. Digital handheld scanners, robots and other specialised industry – or occupation-specific computer-based machines (e.g. lasers, CT scans) – underlie this link. Workers who merely use or operate such digital equipment without engaging in more sophisticated tasks (e.g. maintain or repair or programme them), typically have relatively high-routine jobs.

Figure 41. Digitalisation and changing job routinisation and complexity, EU+, 2020-21



NB: The bars show the difference between digital and non-digital jobs in the shares of workers with a net gain in time (more/less time) spent on each individual activity. For example, 30% of EU+ workers who had to upskill digitally spent more time learning new things at work, but 13% spent less time. 17% of employees in digital jobs therefore saw more learning in their job over the year. 15% of those who did not have to upskill digitally spent more time learning at work but 16% less time (a net change of -1%). The overall net gain in time spent on learning activities for workers in digital jobs is therefore 18%, calculated as [17% for jobs with digital upskilling – (-1%) for jobs without digital upskilling].

Source: Cedefop second European skills and jobs survey, 2021.

#### 4.4.3. Digitalisation and changing task content

For most EU+ workers the amount of time spent on different work activities, which jointly determine job complexity and routinisation, did not change substantially in 2020-21 (Figure 40). For a third to a quarter of workers the time allocated to different activities changed.

The most pronounced changes concern time spent on learning (+35%), reacting to new situations (+30%) or working on varying assignments (+29%). These changes, which are mostly driven by developments in more skilled occupations, likely reflect the volatility and unpredictability workers faced because of COVID-19 and the emergency measures that followed. The marked fall in time spent doing physical and hazardous activities, especially among semi-skilled (26%) and skilled professionals (26%), mirror social distancing and more work from home. 14% of EU+ workers experienced growing standardisation of their tasks, because they had to follow more work instructions while having less discretion in choosing work methods and tools. Workers in elementary jobs (18%) and semi-skilled professions (17%)

particularly saw their autonomy shrink.

EU+ workers who had to learn new digital technologies for their job during 2020-21 were more likely to see net gains in job complexity, compared to those unaffected by technological change (Figure 41). Compared to those not affected by digitalisation, more workers who had to upskill digitally spent time on repetitive and standardised tasks. The trends result in a small net increase in the share of routine jobs in the EU+ labour market. Growing work routinisation is particularly visible for employees who had to learn how to use new digital machines in their job. These workers also spent significantly more time doing physical or hazardous work.

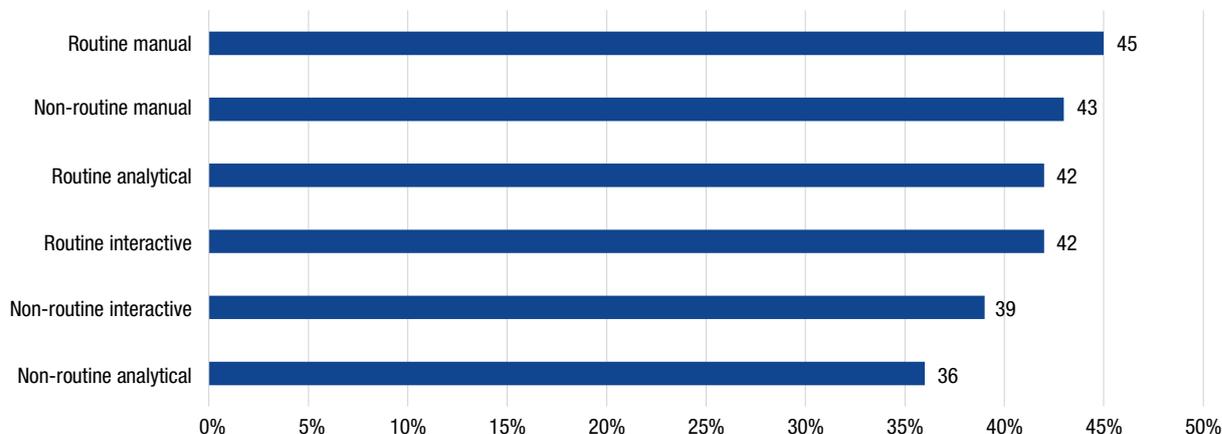
### 4.5. Digital technology and job quality

#### 4.5.1. Automation, polarisation and job insecurity

The job-task churning and routinisation workers affected by technological change face may breed

Figure 42. **Job insecurity and routine-biased polarisation, EU+, 2020-21**

F\_LOSEJOB: DO YOU THINK THERE IS ANY CHANCE AT ALL OF YOU LOSING YOUR MAIN JOB IN THE NEXT 12 MONTHS?



NB: See Annex 3 for explanation of the methodology used to derive the different types of jobs.

Source: Cedefop second European skills and jobs survey, 2021.

feelings of job insecurity. Taking the RBTC hypothesis as a starting point would reasonably imply that fear of job loss is particularly pronounced in the middle-skill segment of the labour market. If the assertion that such jobs have borne the brunt of automation technologies in recent decades is true, job insecurity should be higher among workers with middle-skill, routine-manual occupations. It should also be pronounced for workers whose tasks were displaced by new digital technologies, particularly digital machines and robots.

About four in 10 EU+ workers (38%) are afraid of losing their jobs in the short-term (next 12 months). Workers in eastern Europe (e.g. Slovakia, Bulgaria, Slovenia), the Baltics and south European countries (e.g. Greece, Spain) are more insecure about keeping their job than those in Central and Nordic European countries. The fear of job loss is significantly higher among the lower-educated (41%), compared to those with middle (38%) or high (36%) education level. Middle-level VET graduates feel more secure about their job (37%) than their general orientation counterparts (41%).

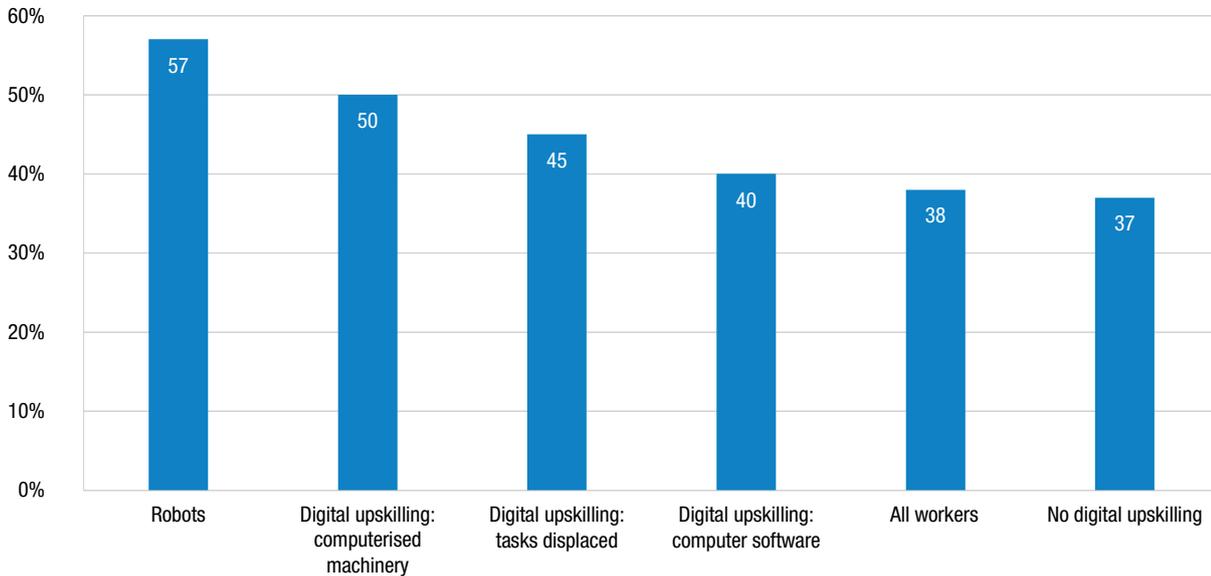
EU+ adult workers in middle-skill occupations (e.g. skilled agricultural workers, craft and related trades, plant and machine operators) are more concerned about the prospect of employment loss than skilled and semi-skilled employees. Workers with very high routine jobs that carry out manual tasks are most fearful of job loss (45%) (Figure 42).

Workers in non-routine, analytical jobs who carry out mostly non-repetitive job tasks and require significant problem-solving and learning capacities are much less insecure (36%) about their jobs. Workers with jobs that rely heavily on interpersonal skills are less afraid of losing them, although less so when such skill demands are accompanied by work routinisation. The findings are broadly in alignment with the underlying premise of RBTC theory, which considers the job-destruction potential of automation to be highest in routine and manual jobs.

Confirming the findings reported by McGuinness et al. (2021), European workers are more afraid of losing their jobs when they need to up-skill digitally: 41%, against 37% for those who did not have to master new digital technologies. The same holds for adults in high digital intensity jobs (46%), who experience significantly higher job insecurity compared to those in jobs with medium or low digital intensity. High job insecurity is also prevalent among non-users of digital technology at work (42%). It seems that the threat of unemployment not only looms larger for individuals excluded from the benefits digitalisation offers, but also for those in the technological vanguard. The latter may be more aware of the capabilities of innovative digital technologies and their automation potential.

The job polarisation hypothesis can be further put to the test by looking at the fear of job loss among European workers impacted by dif-

Figure 43. Types of digital technology and job insecurity, EU+, 2020-21



Source: Cedefop second European skills and jobs survey, 2021.

ferent types of digital or automating technology (Figure 43). More afraid of job loss are workers operating robots at work (57%) and those who had to learn new computerised machines (50%); this is significantly above the perceived risk of job loss among workers unaffected by technological innovation (37%). 45% of adult workers who learned new digital technologies that displace their job-tasks also report high job insecurity. Adult employees who had to learn new computer software are more optimistic, with 40% thinking it is likely or very likely they could lose their job, although this is still higher than for those not affected by technological change (37%). Skilled agricultural workers (64%) and plant and machine operators (53%) are most worried about losing their job, especially when they are affected by technological change that could automate their tasks. But half of all employees in elementary occupations (52%) affected by task automation also perceive high chances of job loss, indicative of skill-biased technological change and occupational downgrading taking effect in European job markets rather than job polarisation (Oesch and Piccitto, 2019; Eurofound, 2016).

#### 4.5.2. Digitalisation, earnings and job satisfaction

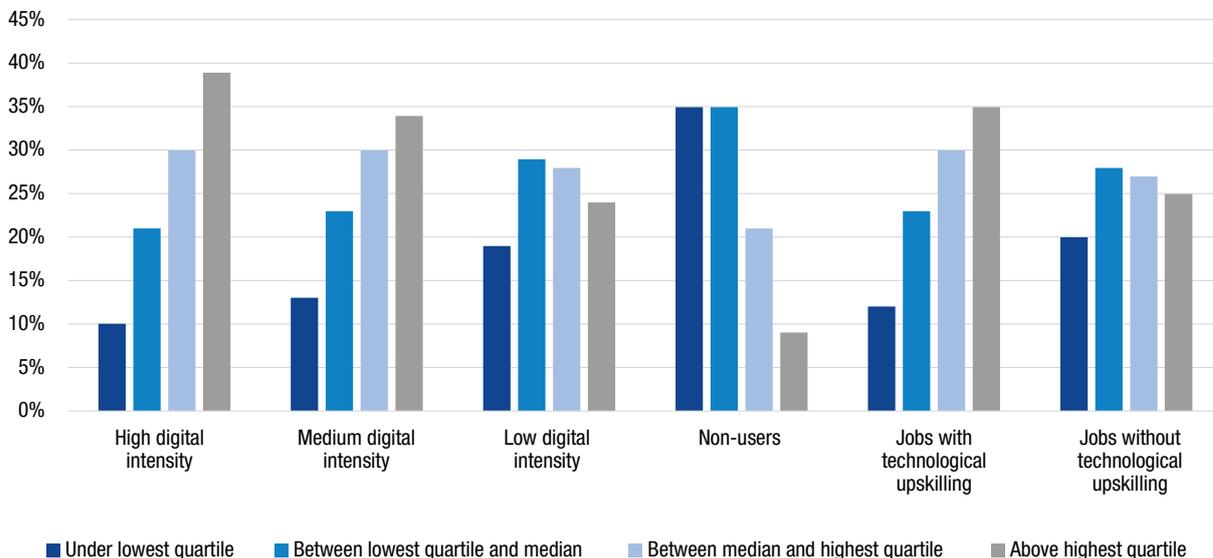
EU+ jobs with higher digital intensity are typically

higher quality jobs, as they are associated with more advanced job-skill requirements, greater autonomy, more in-work learning and less routinisation. Digitally intensive jobs also pay better (Figure 44). About two in five EU+ workers with a high digitally intensive job have net monthly earnings above the highest quartile of their national income distribution. This is significantly more than the 9% of non-users of digital devices and the 24% of workers in low digitally intensive jobs earning such a wage. For 65% of those who had to digitally upskill in 2020-21, net monthly pay amounts to more than the national median. The same is true for 52% of adults in jobs not affected by digital innovation.

ESJS2 analysis shows that most workers in digital jobs are very satisfied with their job (53%); this is more than their counterparts with a low digitally intensive job (43%) and higher than the share of very satisfied technology non-users (43%) (Figure 45). This job satisfaction premium reflects the extrinsic and intrinsic job features (e.g. lower routinisation, higher job-skill demands, greater job complexity, non-manual tasks) making more digitally intensive jobs more attractive. Undertaking more advanced digital activities and having to learn to use new digital technology does not, in itself, result in higher job satisfaction, as it is mediated by the above job features.

Figure 44. Digitalisation and earnings, EU+, 2021

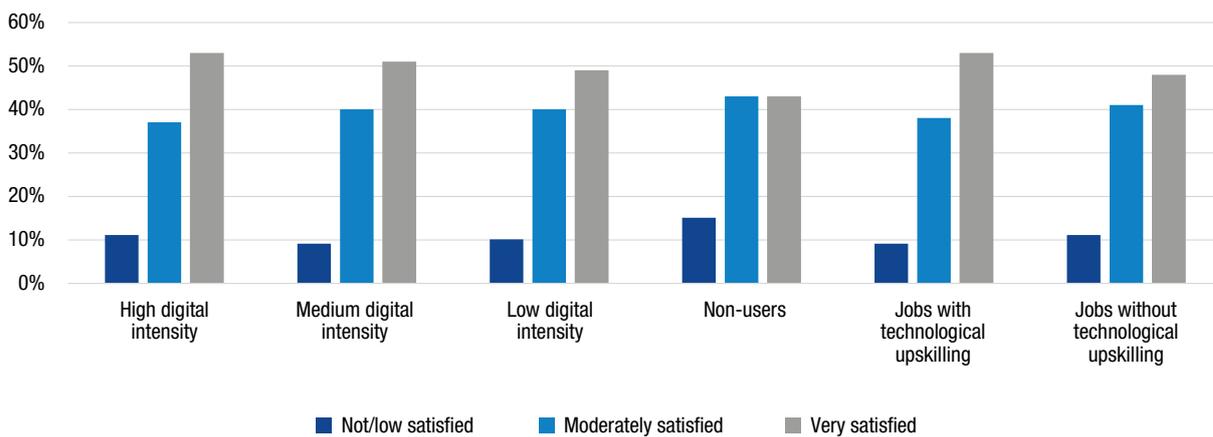
F\_PAY: WHAT IS YOUR USUAL MONTHLY NET PAY AFTER DEDUCTIONS FOR TAX, SOCIAL INSURANCE AND ANY OTHER COMPULSORY DEDUCTIONS?



NB: Quartiles are calculated based on the usual monthly net pay in each country.  
 Source: Cedefop second European skills and jobs survey, 2021.

Figure 45. Digitalisation and job satisfaction, EU+, 2021

F\_JOBSAT: ON A SCALE FROM 0 TO 10, WHERE 0 IS COMPLETELY DISSATISFIED, 5 MODERATELY SATISFIED AND 10 IS COMPLETELY SATISFIED, HOW SATISFIED ARE YOU, OVERALL, WITH YOUR JOB?



NB: 'Not/low satisfied' are workers with job satisfaction scores between [1-4]. 'Moderately satisfied' workers are those with job satisfaction scores in the [5-7] range. Workers with job satisfaction in the [8-10] band are classified as 'Very satisfied'.  
 Source: Cedefop second European skills and jobs survey, 2021.

### Key ESJS2 statistics on the nature of digital work in the EU+

**14%** of EU+ workers do not perform some tasks they did before, because of new digital technologies they had to learn



**18%** of EU+ employees have a manual job with very high physical strain

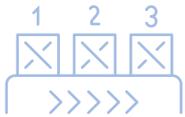


**27%** of EU+ workers do not have to read any text at work, while **25%** usually read less than five pages



**6 in 10** jobs in Europe have at least moderate routinisation

**17%** of jobs have a very high routine intensity



Over half (**52%**) of all EU+ jobs have low skill demands for **31%** skill demands are moderate and for **17%** they are high



**45%** of EU+ adult workers in routine-manual jobs are afraid of losing their job, more than the **36%** in non-routine, analytical jobs



Source: Cedefop second European skills and jobs survey, 2021.

# Skill mismatch in digital labour markets

Skills mismatches have significant costs for economies, companies and individuals (Vandeplas and Thum-Thysen, 2019; McGowan and Andrews, 2015; Polachek et al., 2017; McGuinness et al., 2018). Achieving a better match of skills with labour market needs and making better use of skills at work have been priorities in European skills agendas (European Commission 2016; 2020) and key issues of concern for social partners (ETUI, 2019; Business Europe, 2019).

Mismatches between education and work can take many forms (McGuinness et al., 2018; Brunello et al., 2019; Cedefop, 2010). Cedefop (2015a, 2018a) provides an in-depth overview of the incidence and determinants of skill mismatches affecting European adult workers, based on data from the first European skills and jobs survey. With several industries hit hard by the COVID-19 pandemic and a large share of the workforce becoming detached from the labour market, there is renewed interest in the extent to which the post-pandemic world is suffering from labour / skill shortages and rising labour reallocation across firms (Pizzinelli and Shibata, 2022; Manuel and Plesca, 2021).

This chapter presents updated evidence on different types of skill mismatch affecting EU+ workers. The chapter first reviews so-called educational or qualification mismatches in terms of level (vertical) and field-of-study (horizontal). It then analyses skill gaps of EU+ employees, defined as the need to further develop skills to improve productivity at work. The measured gaps in specific skills, including digital skills, provide insight into the unexploited potential of the European economy, and help make the case for further investing in VET to mitigate them.

The chapter also investigates skills underutilisation at work (Russo, 2017), another major skill mismatch dimension inhibiting labour productivity and wellbeing. The chapter concludes with analysis of the relationship between skill mismatches and labour market outcomes in European job markets, with emphasis on how digitalisation is linked to discrepancies between workers' skills and the skill needs of their job.

## 5.1. Qualification mismatches

### 5.1.1. Educational requirements of jobs

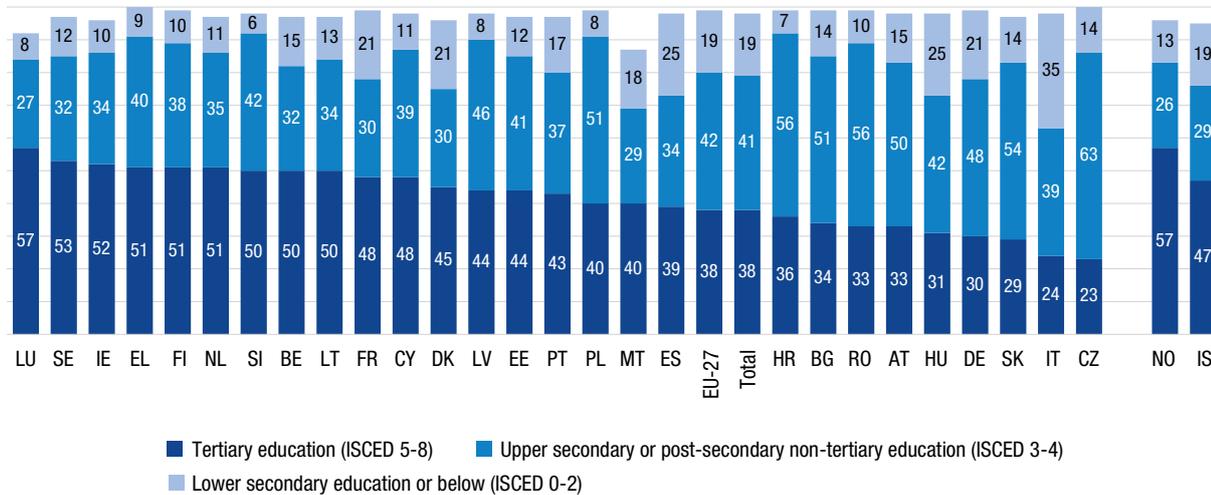
Chapters 3 and 4 provided detailed insight into the job-skill requirements of EU+ jobs. A much broader proxy of the skill requirements of jobs is the education level required 'to do' them<sup>(15)</sup>. Most of the discussion on education mismatches in European countries focuses on whether higher education institutions educate too many graduates, providing labour markets with skills they do not fully need (McGuinness et al., 2020; Korpi, 2021).

Reinforcing the notion that Europe shifts towards becoming a 'knowledge economy', Cedefop's first European skills and jobs survey showed that, in 2014, about 33% of adult workers in the EU required a tertiary education degree to perform their job (Cedefop, 2015a). For 40%, their job could be done with a medium-level, mostly vocational, qualification, while 21% of jobs only needed a lower secondary qualification or below. ESJS2 shows that, in 2021, almost four in 10 (38%) EU+ employees are in jobs that require a tertiary education level (ISCED 5-8) to carry out the required tasks. Attesting to the continued and

<sup>(15)</sup> Using the subjective opinions of employees to detect the level of education required in jobs has several advantages relative to alternative measures used in literature. They directly refer to an individual's job and rely on the information set of the job holder. This may come at a cost of measurement error, given that workers may not be fully aware of the work realities prevailing outside their own information bubble (Brun-Schammé and Rey, 2021; Brunello et al., 2019). Methods that detect qualification requirements based on the mean or modal level of education attainment within broad occupation groups or categorise jobs normatively using international occupation classifications (Leuven and Oosterbeek, 2011; Pouliakas, 2012) are affected by the endogenous influence of labour supply in occupations and neglect the heterogeneity of skill requirements within broad occupational groups.

Figure 46. Required education level in EU+ jobs

E\_REQED3. WHAT IS THE LEVEL OF EDUCATION USUALLY NEEDED NOWADAYS TO DO A JOB LIKE YOUR MAIN JOB?



NB: When the sum of the bars is below 100%, the residual corresponds to Don't know/no answer categories.  
Source: Cedefop second European skills and jobs survey, 2021.

growing importance of medium-level qualifications (ISCED 3-4) in labour markets, 42% of adult employees need them for their job. For 19% of jobs, less than upper secondary education suffices.

Comparing the education level composition of employment between the first and second European skills and jobs surveys suggests growing education requirements over the previous decade. It is important to acknowledge that trends based on subjective measures are also affected by the state of the economy and prevailing skill supply at the time of the survey. Spearheaded by EU priorities, national education policy and reforms which make people aware of the importance of skills, qualifications, lifelong learning, upskilling and continuing VET programmes may also affect individuals' perceptions of what it takes to do a job.

Over five in 10 adult employees in several north European countries (e.g. Norway, Luxembourg, Sweden, Finland, Netherlands) alongside Ireland, Greece and Slovenia, believe that their job needs tertiary-level education (Figure 46). Italy and Czechia stand out with only 23-24% of employees thinking their job requires a qualification at this level. About one in three jobs (35%) in the Italian labour market, and approximately one in five in Spain, Germany, Denmark and France, require no or low qualifications. In several countries with a low share of jobs requiring higher education

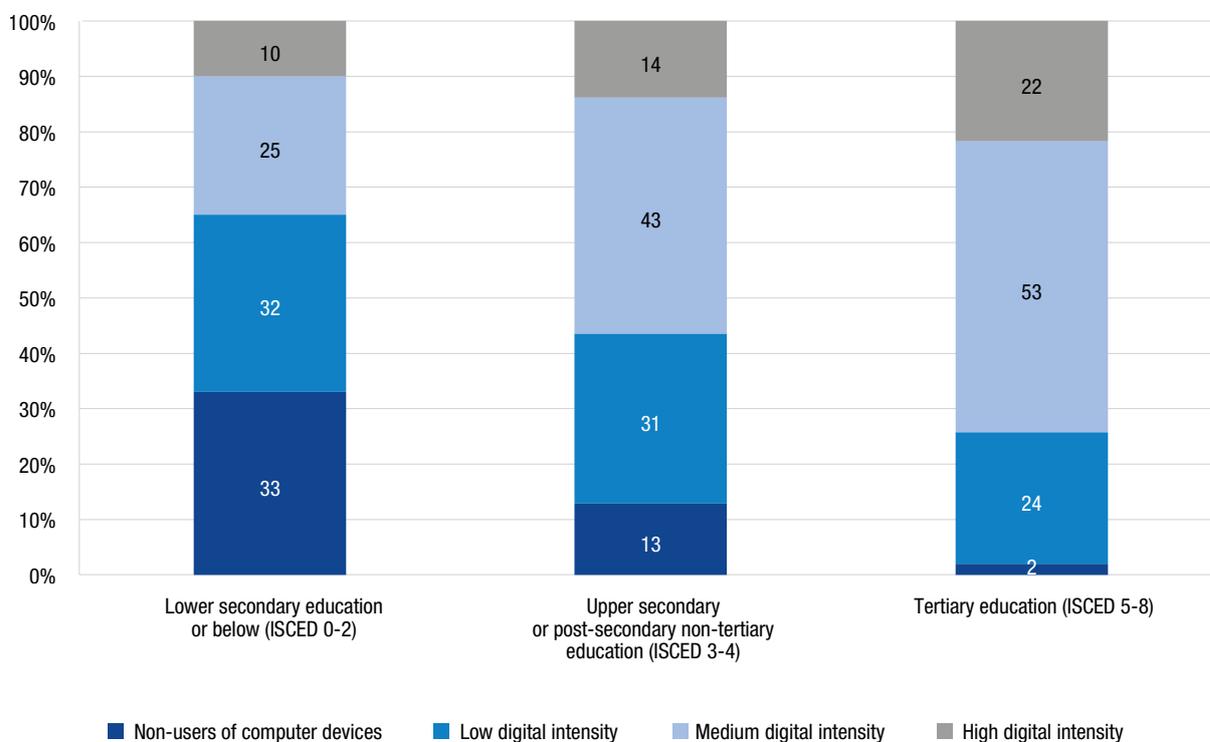
the VET sector is prominent. This explains why in Czechia, Slovakia, Austria and Germany, as examples, the largest share of employment requires an upper secondary or a post-secondary non-tertiary qualification, making up more than half of all jobs.

There is a clear link between the education level a job requires and its digital skills intensity (DSI). Jobs requiring tertiary education tend to have a higher DSI. Three quarters (75%) of jobs that require tertiary education are at least moderately digitally intensive. By comparison, 57% of posts that require upper secondary education and 35% of those needing no more than lower secondary education are medium to high digitally intensive jobs (Figure 47).

### 5.1.2. Educational mismatch

Vertical qualification mismatches arise when a person's education level deviates from that required by the job. Educational mismatches of this type are of concern as they are associated with loss of graduates' human capital potential, particularly when they are overqualified for their job. They also tend to have significant wage and job satisfaction penalties when compared to similarly educated, matched counterparts (McGuinness et al., 2018; McGuinness and Pouliakas, 2017). Landing a job below one's attained education level can also potentially have persisting – scarring – effects for individuals (Mavromaras et al., 2013a,b);

Figure 47. DSI by level by required education level



Source: Cedefop second European skills and jobs survey, 2021.

for some young graduates it signals early, sometimes ill-informed or constrained, career choices. Underqualification potentially marks a need for individuals to upgrade their qualifications to be in closer alignment to contemporary labour market needs, particularly in the context of lifelong learning or being able to strike more efficient job-skill matches with labour market mobility.

By comparing respondents' educational attainment with the level of education required to do their job, the ESJS2 provides up-to-date estimates of the vertical mismatches affecting the EU+ workforce during the COVID-19 pandemic (Figure 48). The findings suggest that:

(a) four in 10 workers (40%) are mismatched in terms of qualification level;

(b) around 28% are overqualified, having higher levels of education than their job requires;

(c) 12% are underqualified;

(d) 17% of EU+ workers are affected by 'severe' overqualification, meaning that they are employed in jobs substantially below their level;

(e) similarly, about 8% are 'severely' underqualified<sup>(16)</sup> <sup>(17)</sup>.

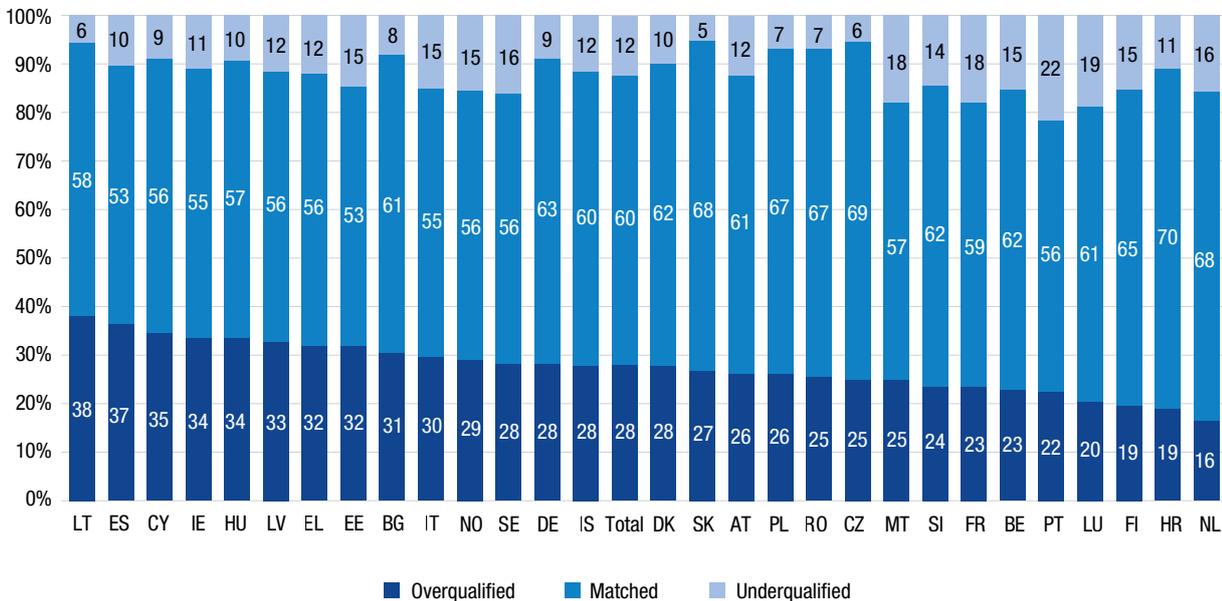
Over three in 10 employees are overqualified for their jobs in Lithuania (38%), Spain (37%), Cyprus (35%), Ireland (34%) and Hungary (34%). Latvia (32%), Greece (32%), Estonia (32%), Bulgaria (31%) and Italy (30%) also have high shares of adult workers in jobs below their qualification level. In the Netherlands (16%), Croatia (19%) and Finland (19%), overqualification is relatively

<sup>(16)</sup> Severe overqualification reflects, for instance, situations where graduates are employed in jobs below their own ISCED level, for instance tertiary education graduates in jobs with medium- or low qualification requirements. 'Mild' education mismatch also refers to situations where workers are employed in jobs that require credentials at their same broad educational level, as is the case with an ISCED 8 graduate in a job where an ISCED 5-7 level qualification is required.

<sup>(17)</sup> The ESJS2 qualification mismatch figures are highly comparable to those obtained from Eurostat 2020 experimental statistics, which use the EU Labour force survey to map severe educational mismatch using an occupation-based, normative approach. Considering only tertiary education graduates, both sources put severe overqualification at 21%. The ESJS2 severe qualification mismatch figures are also broadly comparable with those reported in the first ESJS wave (i.e. 17% overqualification; 12% underqualification) (Cedefop, 2015a). The lower underqualification found using ESJS2 could result from the labour market withdrawal / shift to inactivity of part of the (older) labour force during the pandemic.

Figure 48. **Educational match and mismatch, EU+, 2021**

**E\_HIGHER:** WHAT IS THE HIGHEST LEVEL OF EDUCATION YOU HAVE COMPLETED?  $\geq$  **E\_REQD:** WHAT IS THE LEVEL OF EDUCATION USUALLY NEEDED NOWADAYS TO DO A JOB LIKE YOUR MAIN JOB?



Source: Cedefop second European skills and jobs survey, 2021.

modest. The largest share of matched workers is found in Croatia (70%), followed by Czechia (69%), the Netherlands and Slovakia (both 68%), while the match is weakest in Estonia and Spain (53% of adult workers). Portugal (22%), Luxembourg (19%), Malta (18%) and France (18%) have the highest shares of underqualified workers.

### 5.1.3. Who are the overqualified?

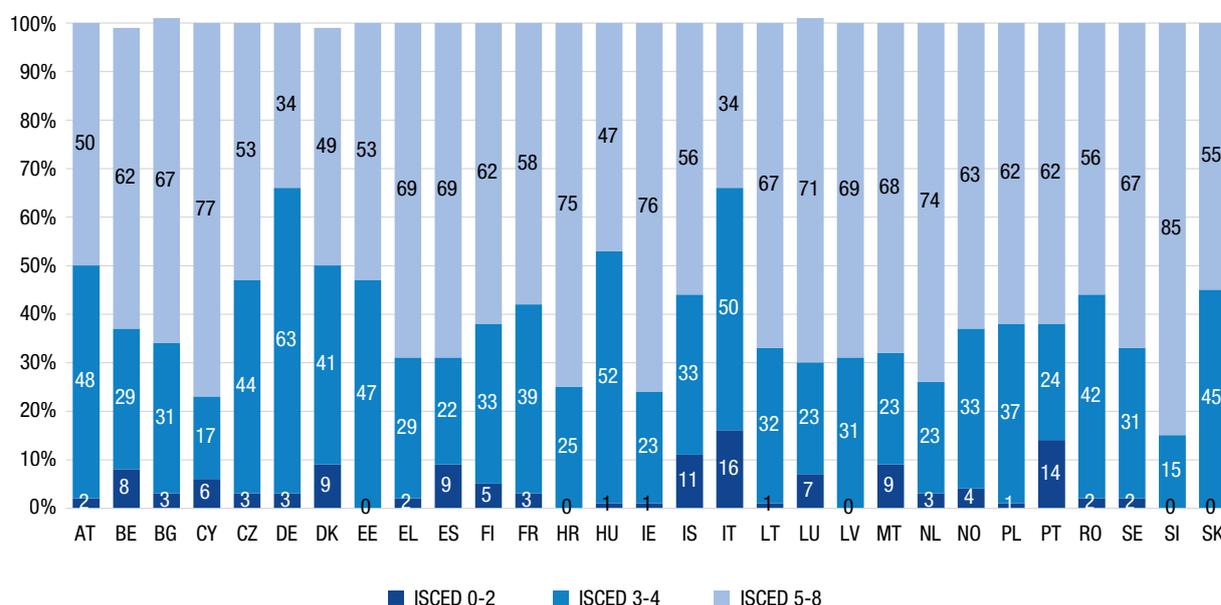
In the public discourse in recent years, overqualification has often been linked to the expansion of tertiary education participation in EU countries. Tertiary education graduates represent the largest share of overqualified workers in the EU+: over one in three graduates (34%) from higher education institutions have qualifications that exceed those required by their jobs. But a non-trivial share – around one quarter (26%) – of medium-educated workers also consider themselves overqualified. In countries with high quality VET systems, medium level overqualification potentially implies significant labour productivity losses. At the lower end of the labour market, 12% of lower-educated employees (e.g. predominantly lower secondary graduates) consider themselves overqualified because they have a low quality job below their own education level.

In countries such as Slovenia, Cyprus, Ireland, Croatia and the Netherlands, a large majority of the overqualified is tertiary education graduates (Figure 49). In Germany, Italy, Hungary and Austria, over half of the overqualified are workers with medium-level education. In Italy, Portugal, Iceland, Spain, Malta and Denmark there is a high share of poor-quality jobs that even low-educated persons consider to be below their own level.

Overqualification in the EU+ is more prevalent among younger employees, females and individuals who were outside the labour market (unemployed or inactive) or self-employed prior to starting their current employment (Tables 4 and 7). Tertiary education graduates with a degree in arts, humanities and languages or social sciences are more likely to be overqualified than those with a degree in health-related, education, engineering or computing sciences. Workers in jobs poorly matching their field of study (horizontally mismatched) often also consider themselves overqualified.

Overqualification is higher among those employed in elementary jobs, or as plant and machine operators. Medium-skilled workers in services and sales and clerical occupations also quite often have higher credentials than their job requires.

Figure 49. Breakdown of overqualification by education level, EU+, 2021



Source: Cedefop second European skills and jobs survey, 2021.

Compared to the education and human health sectors, utilities, manufacturing and construction – where overqualification is relatively low – individuals working in the arts, entertainment and recreation, accommodation or food services, wholesale and retail trade, administrative services and transportation and storage sectors are more likely to be overqualified.

The incidence of overqualification is partly driven by employer and job characteristics. It is higher for people employed in privately owned, small-size firms. Overqualified workers are more frequently found in jobs with non-standard, precarious contracts. They typically carry out high routine tasks with a low level of skill complexity. There is a significant correlation between being overqualified and skills underutilisation. This could explain the lack of incentive to participate in CVET and lacking awareness of the need to develop skills further.

Overqualification rates tend to be higher among those who are less satisfied with their jobs, paid lower wages and in greater fear of losing their job in the near future.

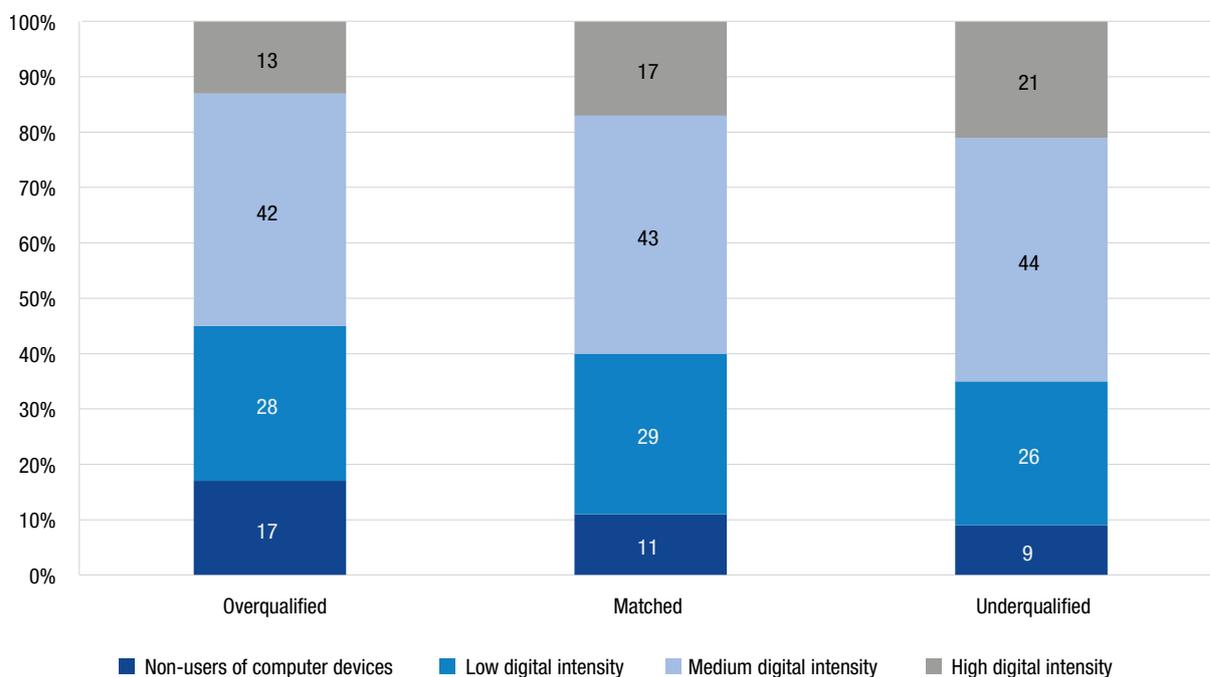
There is an inverse relationship between the extent of digitalisation in a job and the likelihood of feeling overeducated. Non-users of digital devices and workers less exposed to learning new digital technologies are more likely to be overqualified. This negative correlation is evident from the small share of overeducated workers in high digitally intensive jobs. More than four in 10 (45%) overeducated workers are in low digital intensity jobs and one in eight (13%) in high digital intensity jobs (Figure 50).

Table 4. Share of overqualified workers by individual / job characteristics, EU+, 2021

Individual		Job	
Gender		Occupation	
Male	26%	Managers	22%
Female	29%	Professionals	21%
Age group		Technicians and associate professionals	26%
25-34	31%	Clerical support	29%
35-44	28%	Service and sales	34%
45-54	25%	Skilled agricultural	29%
55-64	24%	Crafts and related trades	25%
Education level		Plant and machine operators	31%
Low	11%	Elementary occupations	38%
Medium	25%	Sector	
High	34%	Private	28%
Field of study		Public	24%
General programmes	30%	Not-for-profit	29%
Education	26%	Firm size	
Arts, humanities and foreign languages	39%	SME	29%
Social sciences	39%	Not SME	25%
Business, admin and law	28%	Contract	
Natural sciences, maths and stats	31%	Open-ended/indefinite	26%
ICT	27%	Fixed-term/temporary	34%
Engineering, manufacturing and construction	25%	No contract	31%
Agriculture, forestry and fisheries	32%	Nature of work	
Health and welfare	25%	Always repetitive tasks	33%
Services (personal, security, transport)	32%	Rarely or never repetitive tasks	23%
Horizontal mismatch		Job-skill requirements	
Job exclusively requires field	20%	Low	30%
Job requires your or related field	27%	Medium/high	26%
Job mostly requires different field	38%	Digitalisation	
Job does not require a specific field	54%	New workplace technologies	25%
Previous employment status		No new workplace technologies	29%
Education and training	24%	User of computer devices	26%
Employed in other job	27%	Non-user of computer devices	37%
Self-employed	31%	Digital upskilling	26%
Unemployed	31%	No digital upskilling	28%
Inactive	34%	Job satisfaction	
Participation in education and training		Not satisfied	35%
No	29%	Moderately satisfied	31%
Yes	26%	Satisfied	24%
Weekly earnings band		Lose job	
Under lowest quartile	36%	No	26%
Lowest-median	30%	Yes	29%
Median-highest quartile	25%	Skill utilisation (use skills at work)	
Above highest quartile	22%	Great/moderate extent	25%
		Small extent/not at all	41%

Source: Cedefop second European skills and jobs survey, 2021.

Figure 50. Educational mismatch and DSI, EU+, 2021



Source: Cedefop second European skills and jobs survey, 2021.

#### 5.1.4. Who are the underqualified?

Contrasting the patterns found for the overqualified, EU+ workers with lower credentials than required by their job (underqualified) tend to be older and work longer for their current employer. They are often low-qualified employees, employed in jobs which are not in their field of study. Underqualification is more pronounced in skilled, non-manual, occupations (e.g. managers and professionals) and in skill-intensive non-routine jobs. The share of underqualified workers is higher in more digitally intense jobs (Table 7). This suggests being underqualified is not necessarily a skill gap/underskilling problem. While they do not have a diploma or credential documenting the education level their job requires, many older underqualified workers have acquired the skills they need via work experience. Overall, the underqualified tend to be satisfied and get paid relatively well in their job.

#### 5.1.5. Horizontal education mismatches

Horizontal mismatches occur when 'workers are employed in jobs that are not relevant to the skills and knowledge accumulated by them in formal education' (McGuinness et al., 2018). The ESJS2

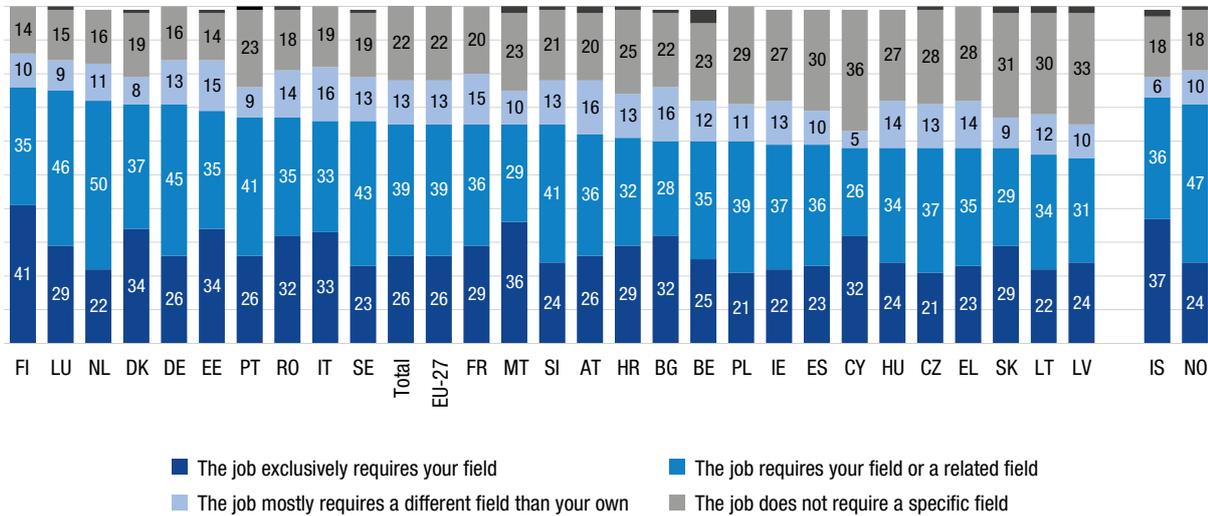
maps the extent to which workers are in jobs that require (i) exclusively their field of education, (ii) their field or a related field, (iii) mostly a different field, and (iv) no specific field. The first two categories are indicators of a relatively strong horizontal match, whereas the third points towards a weak one. The fourth category is residual and captures workers in jobs in which their generic skills may be relevant, but their subject specific skills are not. Therefore, the job position can be open to any field.

Horizontal mismatches appear to be somewhat lower than vertical mismatches (Figure 51). Almost two thirds (65%) of workers are in jobs that require their field of study or a related field. The share of those in jobs that exclusively require their field of study is highest in Finland (41%), while the lowest share is found in Czechia and Poland (both 21%). Horizontal matching is generally weaker in eastern Europe than in other areas of the continent.

Workers in skilled occupations are more often horizontally well-matched than workers in other occupations. Their jobs are most likely (for 30% of them) to require exclusively their field of study. This is around three times higher than is the case for workers in elementary occupations and 50%

Figure 51. Horizontal (field of study) match and mismatch, EU+, 2021

E\_HOZMIS: CONSIDERING YOUR MAIN SUBJECT OR FIELD OF STUDY AT YOUR HIGHEST LEVEL OF EDUCATION (BUSINESS, ENGINEERING, HEALTH ETC.), HOW RELEVANT IS IT FOR DOING YOUR MAIN JOB?

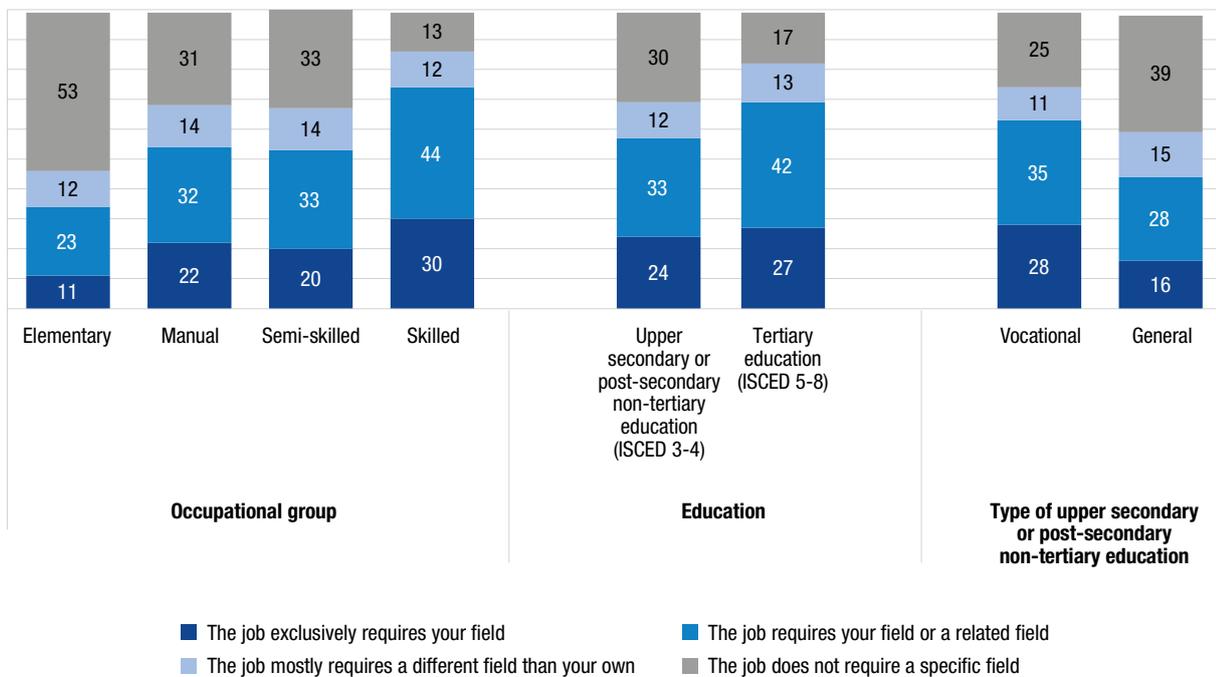


NB: Respondents with at least upper secondary education (above ISCED 3).

Source: Cedefop second European skills and jobs survey, 2021.

Figure 52. Horizontal mismatch by socioeconomic characteristics, EU+, 2021

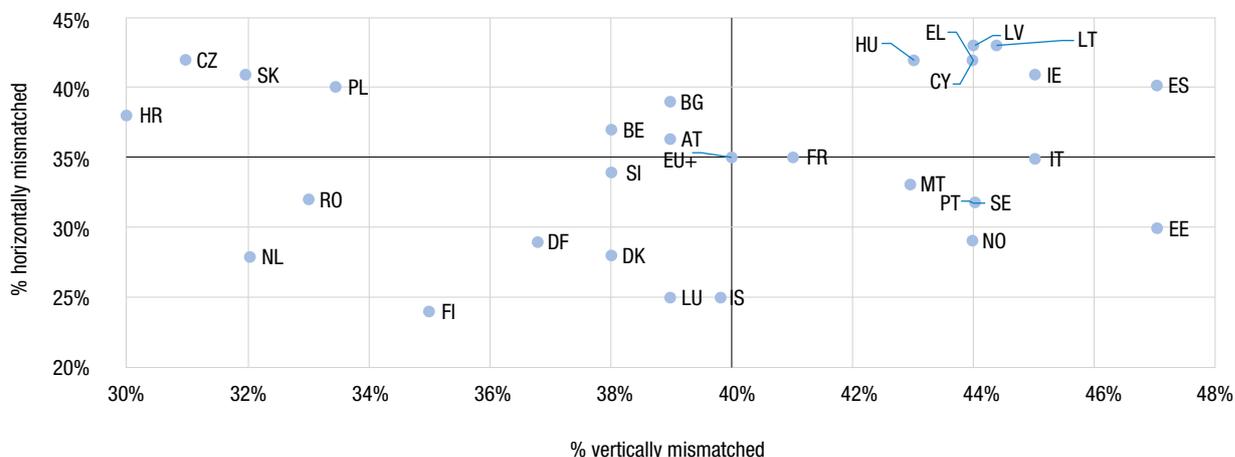
E\_HOZMIS: CONSIDERING YOUR MAIN SUBJECT OR FIELD OF STUDY AT YOUR HIGHEST LEVEL OF EDUCATION (BUSINESS, ENGINEERING, HEALTH ETC.), HOW RELEVANT IS IT FOR DOING YOUR MAIN JOB?



NB: Respondents with at least upper secondary education (above ISCED 3).

Source: Cedefop second European skills and jobs survey, 2021.

Figure 53. Educational mismatch country clusters, EU+, 2021



Source: Cedefop second European skills and jobs survey, 2021.

higher than for workers in manual occupations. At the lower end of the occupational spectrum, elementary occupations employ the largest share of workers in jobs that do not require a specific field (53%), four times the share for workers in skilled occupations (13%).

The share of workers with completed upper secondary or post-secondary, non-tertiary education in jobs that do not require a specific field is much higher, compared to tertiary education graduates (30% versus 17%). Programme orientation also influences horizontal matching. Workers who completed vocational secondary education are more likely to be horizontally matched (64%) than those who completed general secondary education (45%).

#### 5.1.6. Educational mismatch country clusters

Taking as a starting point the EU+ average vertical mismatch (40%) and horizontal mismatch (35%), countries can be organised into four groups. These education mismatch country clusters characterise the severity of total qualification mismatch (Figure 53) <sup>(18)</sup>. Educational mismatch is more se-

vere in some south European countries (Cyprus, Greece, Spain, Italy, Malta) and two Baltic states (Lithuania, Latvia) but also in Ireland, Hungary and France. In these countries, a high share of adult workers are in jobs that are not commensurate to their education level and field of study. In contrast, the labour market appears to achieve better job/people matches in the Netherlands, Finland, Germany, Denmark, Luxembourg and Iceland. Horizontal mismatch is relatively high in some central and Eastern Europe countries (e.g. Czechia, Slovakia, Poland, Croatia). In these countries, many workers manage to find jobs matching their education level, but not field of study.

## 5.2. Skill gaps of European workers

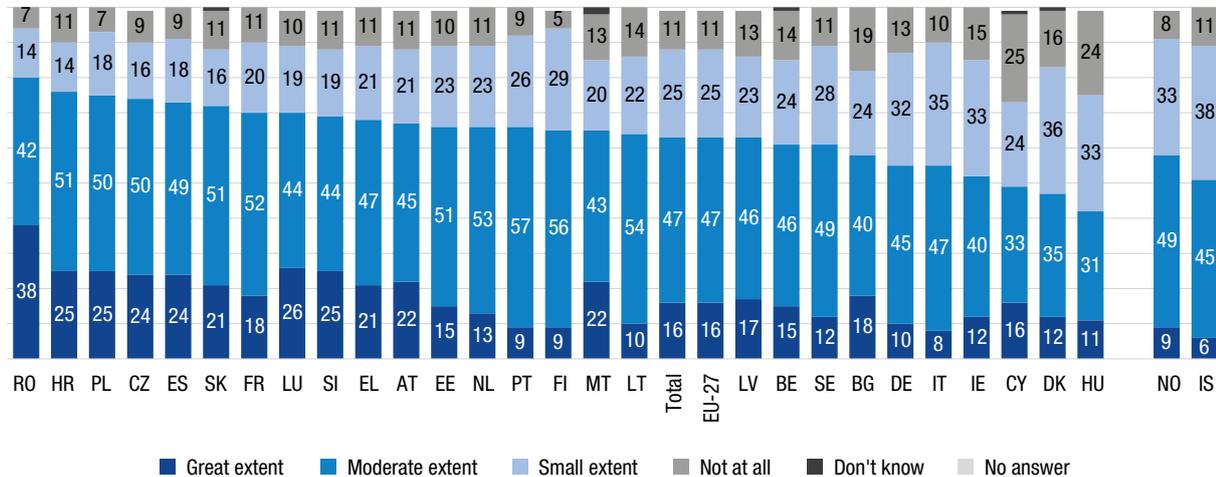
### 5.2.1. Measuring dynamic skill gaps

Skill gaps are defined as situations in which workers do not possess adequate competences to perform their role proficiently (Cedefop, 2010; McGuinness et al., 2018). The ESJS2 goes beyond

<sup>(18)</sup> The horizontal axis (x) represents the share of workers with vertical education mismatch (education level that is higher or lower than what the job requires) in each country where the average is 40%, as represented by the vertical black line. The vertical axis (y) represents the share of those with mismatch in terms of the field of study (horizontal), defined as being in a job that does not require a particular field or one that requires mostly a different field. The EU+ average is 35%, as represented by the horizontal black intersecting line. A country plotted to the left implies lower shares of vertically mismatched in that country relative to the EU+ average, while being on the right means higher vertical mismatch rates than the average. A country plotted on the lower quadrant implies a low share of total mismatched workers relative to the EU+ average, while the upper quadrant denotes countries with high shares of mismatched employees relative to the total average.

Figure 54. Skill gaps of EU+ workers, 2021

E\_SKILLDEF: AND TO WHAT EXTENT DO YOU NEED TO FURTHER DEVELOP YOUR OVERALL LEVEL OF KNOWLEDGE AND SKILLS TO DO YOUR MAIN JOB EVEN BETTER?



Source: Cedefop second European skills and jobs survey, 2021.

simply measuring whether adult workers can carry out their current job tasks given their skillset, as is customary in the ‘underskilling’ literature. Alongside social desirability and other biases affecting responses, most commonly used underskilling measures provide a static assessment of the adequacy of workers’ skills and do not acknowledge that the task profile of most jobs can expand or shrink over time (Chapter 4).

One of the main lessons learned from the first ESJS is that expanding the production possibility frontier of jobs – by providing individuals with appropriate incentives and contextual environmental conditions to support them in reaching their ‘learning potential’ – is a key challenge for adult learning and VET policies (Cedefop, 2015a, 2018a). This is crucial, given that some demand-driven changes in skill needs may be short-lived. Workers’ assessments of whether they can appropriately perform their tasks at a given point in time may reflect erratic trends. The ESJS2 measures the ‘dynamic skill gaps’ of people, not primarily focusing on whether adult employees can perform their job tasks at a given point in time but on how they can overall improve in their job via continuing knowledge and skills development.

On average, six in 10 EU+ workers (63%) feel – to a great (16%) or moderate (47%) extent – that they need to develop their knowledge and skills to improve job performance (Figure 54). Dynamic skill gaps are most widespread in Romania (80%),

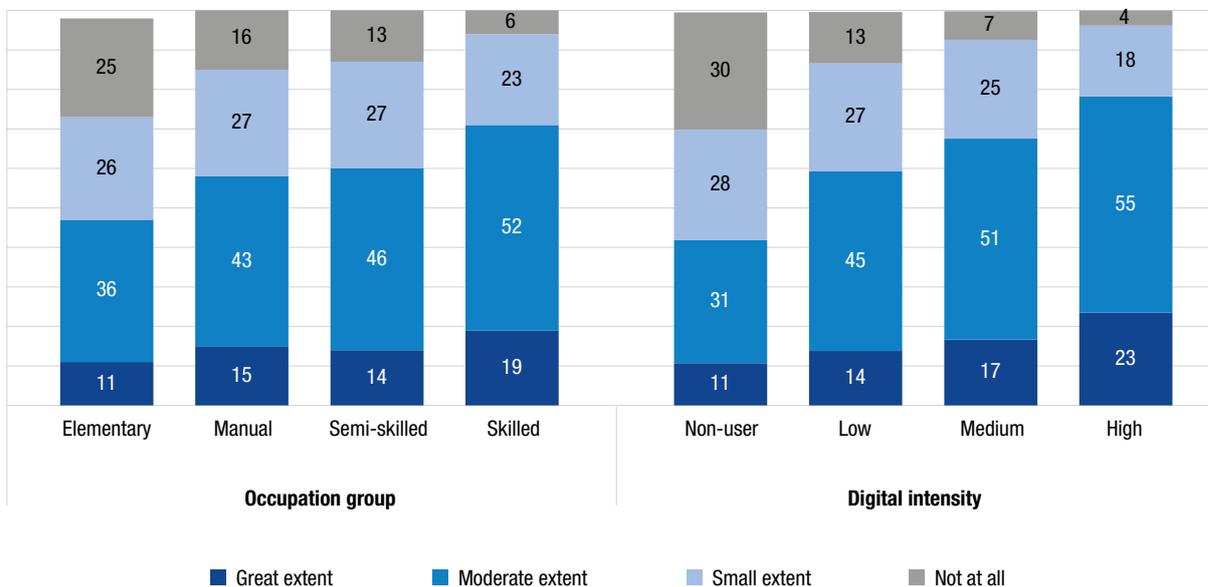
Croatia (76%) and Poland (75%) and least so in Denmark (47%) and Hungary (42%).

Workers in skilled occupations feel the need to develop their knowledge and skills further to improve job performance to a greater extent compared to workers in other occupational groups (Figure 55). Seven in 10 workers in skilled occupations report a significant need for continuing skill development. This signals substantial unmet learning needs among skilled workers in Europe. Dynamic skill gaps are particularly pronounced for workers in complex jobs with higher job-skill requirements, including highly digital intensive jobs (Table 7). In contrast, over half of workers in elementary jobs, and those in jobs with no or little digital intensity, report limited or no skill development needs. Such jobs are often occupied by lower-educated/lower-skilled persons. The fact that many of them do not acknowledge the importance of investing in their human capital or have little learning ambition should be a concern for policy-makers.

Only 54% of low-educated EU+ workers agree that they need to develop their skills further to do their job even better, substantially less than the 71% with tertiary education. Among people with similar socio-demographic characteristics and job features, those with lower education tend to perceive greater skill development needs than their higher-educated counterparts. The lower skill development potential of those with lower qualifications, visible in the

Figure 55. Skill gaps of EU+ workers by occupation group and DSI, 2021

**E SKILLDEF:** AND TO WHAT EXTENT DO YOU NEED TO FURTHER DEVELOP YOUR OVERALL LEVEL OF KNOWLEDGE AND SKILLS TO DO YOUR MAIN JOB EVEN BETTER?



Source: Cedefop second European skills and jobs survey, 2021.

raw data, may therefore be masking their learning constraints in their employment, rather than a lack of awareness or individual want.

Older employees and females are less likely to acknowledge they need to develop their skills further. While for the former this may signal that they have reached a plateau in their age-earnings profile, the gender difference possibly reflects limited career opportunities in jobs typically occupied by females. Workers employed in small and medium-sized enterprises (SMEs), and those with temporary contracts, are also reluctant to say that their skillsets could be further expanded. This is likely to reflect limited career advancement prospects, lacking education and training opportunities, or both (Table 7).

Confirming findings of the first ESJS (Cedefop, 2015a, 2018a), overqualified workers have weaker incentives to invest continuously in their skill formation, compared to those in a matching job or the underqualified. 56% of those with higher education than required by their job have scope to develop their skills further to improve job performance. This is significantly less than the 67% of matched workers and the 69% of the underqualified.

### 5.2.2. Digital skill gaps

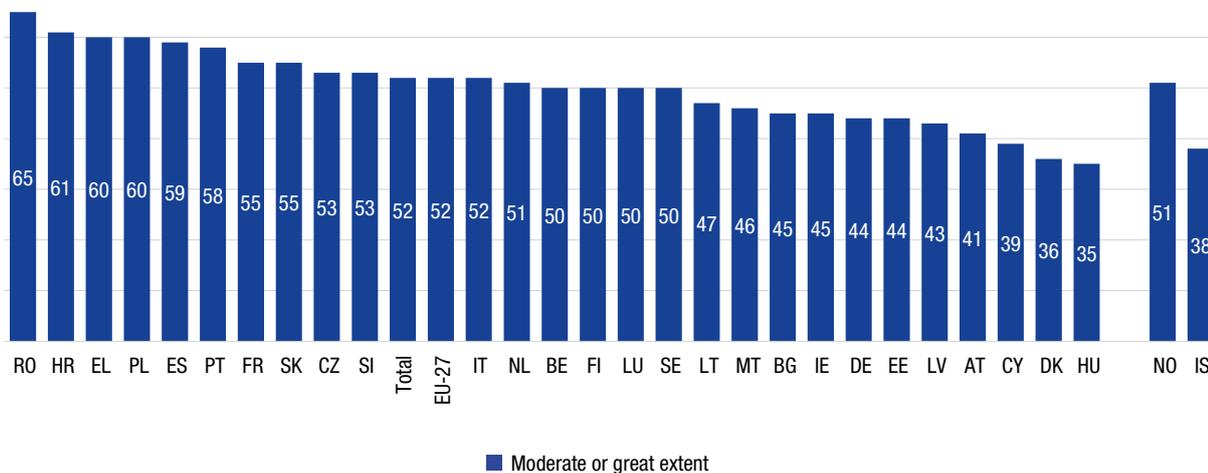
The spread of digitalisation in EU+ workplaces and the resulting need to learn new computer technologies challenge individuals' digital skills. Digitalisation also affects workers in terms of the extent to which they are effectively matched to the job, in the short- and the medium-term.

The ESJS2 shows that 52% of EU+ adult workers need to develop their digital skills further to do their main job better than at present: 13% significantly and 39% to a moderate extent. This digital skill gap, benchmarked to improved future job performance, varies considerably between countries (Figure 56). Adult workers in Romania, Croatia, Greece, and Poland have the greatest potential to develop their digital skills for improved job performance. In Hungary, Denmark, Iceland and Cyprus, only three to four out of every 10 workers have a digital skill gap.

Professionals and those in clerical support roles have the highest need to develop their digital skills further to improve job performance, with 60% feeling a great or moderate need to do so compared to only 37% of those in elementary occupations. Lower-educated and incumbent workers, employed for a long time with the same employer, have greater digital skill gaps. Being

Figure 56. Digital skill gaps of EU+ workers, 2021

E\_DEFPC: TO WHAT EXTENT DO YOU NEED TO FURTHER DEVELOP YOUR COMPUTER/IT SKILLS TO DO YOUR MAIN JOB EVEN BETTER?



Source: Cedefop second European skills and jobs survey, 2021.

employed in a large organisation or in the public sector is also associated with having higher digital skill gaps. The same holds for non-routine jobs with high job-skill requirements (Table 7).

Adults employed in organisations where new digital technologies were introduced, and those in jobs with high digital intensity, are more likely to have a digital skill gap, which, if addressed would improve job performance. Over six in 10 (62%) EU+ adult workers affected by changing digital technology have a digital skill gap, in contrast to four in 10 (44%) in organisations where no new digital technology was introduced. Similarly, 75% of workers in high digitally intensive jobs have a great or moderate need to develop their digital skills further, compared to 22% of those in jobs that are not digitally intensive.

### 5.2.3. Skill gaps in using digital applications

The detail given above quantifies the EU’s marked scope for further adult education and training investments to mitigate the workforce’s digital skill gaps in broad terms. The ESJS2 also maps the potential for skills development for a range of digital activities. It does so by identifying non-users of computing devices at work who do not know how to do such activities, and computing device users who do not regularly carry them out at work (Table 5). Non-use of digital activities at work tends to be a factor in low or no digital skill pro-

iciency, since idleness can induce or accelerate skills depreciation and prevent learning (Centeno et al., 2022). It is also reasonable to expect that not regularly using digital activity at work fosters continuing skill development needs in rapidly changing workplaces.

The approximately one in eight (13%) EU+ employees who do not use computer devices at all to do their job, or the 9% who have neither used digital devices nor computerised equipment, are more likely to have fundamental digital skill gaps. The ESJS2 finding, that over seven in 10 of such workers have also not used computing devices in previous or other jobs, supports this claim.

About one in every five EU+ adult workers, and 31% of non-users of computer devices, could benefit from additional training in the most basic of digital skills: navigating the web (Table 5). Between 30-40% of the EU+ workforce can be further trained in fundamental word processing and use of spreadsheets. Between 70-90% is trainable for more advanced digital skills, such as database management and computer programming.

### 5.2.4. Other skill gaps

To maximise job performance, alongside digital skills, workers need a wider set of other core and soft skills (Cedefop, 2018a). The ESJS2 measures the extent to which EU+ workers have potential to develop their numeracy, social and technical/

Table 5. Skill gaps in digital activities, EU+

	% of non-users who do not know how to use a computing device to do the following activities	% of users who do not use computing devices to do the following activities in their job	% of all EU+ adult workers with potential digital skill gap in specific computer activity
Use the internet for browsing, sending emails or using social media	31%	28%	20%
Write or edit text	44%	35%	28%
Use spreadsheets	65%	43%	38%
Use specialised, sector- or occupation-specific, software	87%	52%	50%
Prepare presentations for work	69%	64%	60%
Use advanced functions of spreadsheets e.g. macros or complex formulas	74%	75%	74%
Manage or merge databases	94%	82%	81%
Develop or maintain IT systems, hardware or software	94%	87%	87%
Write programmes or code using a computer language	96%	93%	92%

NB: Column (3) combines the share of non-digital users who do not know a specific digital activity (Column 1) with users who do not deploy such activities at work (Column 2); weighted data.

Source: Cedefop second European skills and jobs survey, 2021.

job-specific skills further (Figure 57). Almost half (49%) of all EU+ employees acknowledge they need to upgrade their social skills, to work with and deal with colleagues and other people (e.g. customers, clients, students, patients). 40% needs to further develop their technical skills, while 29% acknowledges a numeracy skills deficit.

Workers who are already well educated or highly skilled are typically much more likely to perceive further skill development needs than workers with less human capital, and will also be more likely to take action to meet them. This reinforces and widens inequalities in skills distribution in Europe.

### 5.3. Skills underutilisation

Apart from highlighting the lost human capital potential of workers associated with educational mismatch, research has established that labour market outcomes for individuals are most severely affected when overqualified workers also do not use their skill at work (Sloane and Mavromaras, 2020). Recognising that being mismatched in terms of education level does not necessarily equate with mismatches in individuals' skills, policy-makers have become increasingly concerned with skills utilisation (Payne, 2012; McGuinness et

Figure 57. Skill gaps of EU+ workers, 2021

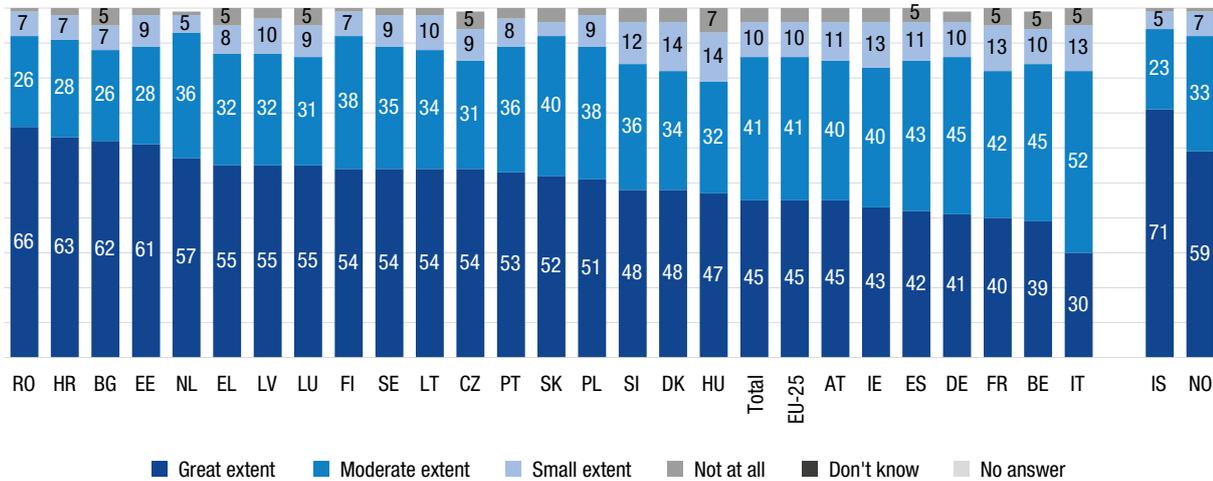
E\_DEF\*: DO YOU NEED TO FURTHER DEVELOP ANY OF THE FOLLOWING SKILLS TO DO YOUR MAIN JOB EVEN BETTER?



NB: The question on computer/IT skills was asked to all respondents, while the questions for all other skills were asked only to online ESJS2 respondents. Source: Cedefop second European skills and jobs survey, 2021.

Figure 58. Use of knowledge and skills in EU+ jobs, 2021

E\_SKILLU: TO WHAT EXTENT CAN YOU USE YOUR CURRENT KNOWLEDGE AND SKILLS IN YOUR MAIN JOB?



NB: Question asked only to online ESJS2 respondents; no data are available for Cyprus and Malta; weighted data.  
Source: Cedefop second European skills and jobs survey, 2021.

al., 2018; Mavromaras et al., 2013a,b). Research has examined whether part of the productivity loss typically associated with overqualification simply reflects unobserved individual traits (e.g. lower ability). ‘Real’ unexploited human capital potential is the result of overqualified workers not making good use of their skills at work (Green and Zhu, 2010; Chevalier and Lindley, 2009).

Slightly less than half (45%) of the adult workers in the EU+ can use their current knowledge and skills to a great extent in their main job (Figure 58). For the other 55%, part of their knowledge and skills is underutilised, as they can only use it to a moderate (41%) or small extent (10%), or not at all (4%). The bandwidth of perceived skills utilisation is wide. Employees in Iceland (71%) are most likely to feel that their skills are put to very good use; this is the case for less than a third (30%) of Italian workers.

In their education-to-work transition, younger workers often face difficulties in finding a matching job, often leading them into accepting entry-level or part-time jobs as a stepping stone towards more matched employment in the future. This is mirrored in their skill underutilisation rates exceeding those of older workers or employees with longer job tenure. Males are more likely to say that they cannot fully deploy their skills at work than females.

49% of highly educated workers use their knowledge and skills to a great extent, which is slightly higher than for those with upper secondary (44%) and considerably above the skills utilisation among workers with lower secondary education (35%). Medium-qualified workers with a vocational qualification use their knowledge and skills at work to a greater extent than secondary general education graduates (49% versus 37%). This reinforces the notion of knowledge and skills acquired in VET tracks being more closely aligned to labour market needs.

High skills utilisation is more common in skilled occupations. More than half (53%) of workers in such occupations can use their knowledge and skills at work to a great extent. In contrast, the majority of workers in semi-skilled (59%) (e.g. clerks, salespersons), manual (59%) (e.g. plant and machine operators) and elementary (73%) occupations do not fully use their skills potential at work.

To some extent, not being able to use one’s skills fully reflects under- or precarious employment, given that it is more frequently reported by individuals who work fewer hours, cannot work remotely or have a temporary contract.

Job-skill complexity and skill-requirements jointly determine the extent to which people use their skills at work, confirming that people-centred managerial, personnel and job design practices can foster skills utilisation (Cedefop-Eurofound, 2020) (Table 7). As an (extreme) example, the ESJS2 analysis shows that 74% of non-users of computer devices know how to do at least one of the digital activities included in the survey. More than four out of 10 know how to do some basic digital functions (e.g. web browsing, word-processing or using spreadsheets), 9% know those at moderate level (e.g. database management) and 6% are skilled enough to undertake advanced digital activities (e.g. coding). Yet, only about one in 10 non-users of digital devices with a high digital skill level have secured a job with high foundation job-skill requirements; 59% of them are employed in very low-skilled jobs that essentially demand no literacy or numeracy skills.

Six in 10 overqualified workers do not use their skills well at work (so-called real overqualification) or are dissatisfied with their job's match with their qualifications and skills (so called genuinely overqualified) (Table 6). This group represents about 16% of the EU+ adult workforce. The individuals who are part of it do not effectively exploit the value of their qualifications and skills. For workers in jobs matching their education level, skills underutilisation is also quite common: about half of them (53%) make poor use of their skills at work. For the underqualified, skills underutilisation is at similar levels: 52% of workers with qualifications lower than required by their job do not effectively deploy their skills.

Table 6. **Education and skill mismatch, EU+, 2021**

	Skill utilisation		Satisfaction with match	
Education mismatch	Overskilled	Matched	No	Yes
Overqualified	61%	39%	59%	41%
Matched	53%	47%	49%	51%
Underqualified	52%	48%	51%	49%

NB: Online ESJS2 respondents only.

Source: Cedefop second European skills and jobs survey, 2021.

Table 7. **Determinants of education and skill mismatch, EU+**

	(1) Overqualified	(2) Underqualified	(3) Skill gap	(4) Digital skill gap	(5) Overskilled
<b>Age group</b>					
35-44	-0.02 (0.034)	0.01 (0.031)	-0.04 (0.027)	0.03 (0.027)	-0.09** (0.039)
45-54	-0.00 (0.046)	0.03 (0.042)	-0.11*** (0.026)	0.03 (0.038)	-0.20*** (0.029)
55-64 (Ref: 25-34)	0.03 (0.021)	0.05* (0.030)	-0.21*** (0.029)	-0.04 (0.036)	-0.29*** (0.024)
Male	-0.03* (0.017)	-0.03 (0.016)	0.06*** (0.017)	0.03 (0.024)	0.05** (0.021)

	(1) Overqualified	(2) Underqualified	(3) Skill gap	(4) Digital skill gap	(5) Overskilled
<b>Education</b>					
Upper secondary or post-secondary, non-tertiary	0.84*** (0.118)	-0.69*** (0.043)	-0.04 (0.051)	-0.03 (0.029)	-0.07 (0.043)
Tertiary education (Ref: below lower secondary)	1.52*** (0.073)	-1.60*** (0.104)	-0.08 (0.050)	-0.09*** (0.021)	0.02 (0.049)
Employer tenure (years)	-0.01*** (0.001)	0.01*** (0.002)	-0.00 (0.001)	0.01*** (0.001)	-0.01*** (0.001)
Private sector	0.02 (0.041)	-0.03 (0.044)	-0.02 (0.016)	-0.04** (0.018)	-0.10*** (0.033)
SME	0.09*** (0.031)	0.00 (0.027)	-0.03 (0.020)	-0.08*** (0.020)	-0.01 (0.016)
Permanent contract	-0.03 (0.044)	-0.01 (0.048)	-0.06** (0.025)	-0.00 (0.033)	-0.09** (0.037)
Weekly work hours	-0.00 (0.001)	-0.00 (0.001)	0.00 (0.001)	-0.00** (0.001)	-0.00*** (0.001)
Remote work	0.04*** (0.014)	0.07** (0.034)	0.01 (0.013)	-0.02 (0.021)	-0.06*** (0.023)
<b>Job-skill requirements</b>					
Literacy skills	-0.09*** (0.020)	0.07*** (0.014)	0.08*** (0.015)	0.13*** (0.022)	-0.04*** (0.014)
Numeracy skills	-0.01 (0.013)	0.05*** (0.015)	0.03** (0.016)	0.02* (0.009)	-0.06*** (0.014)
Social skills	-0.02 (0.036)	0.06** (0.029)	0.12*** (0.027)	0.04* (0.022)	-0.03 (0.026)
Manual skills	0.20*** (0.044)	-0.23*** (0.023)	-0.00 (0.040)	-0.10*** (0.024)	0.19*** (0.035)
Digital skills	-0.09*** (0.023)	0.09*** (0.023)	0.13*** (0.019)	0.29*** (0.021)	-0.01 (0.018)
<b>Work organisation</b>					
Job complexity	-0.15*** (0.012)	0.07*** (0.012)	0.37*** (0.013)	0.28*** (0.024)	-0.36*** (0.025)
Work routinisation	0.15*** (0.023)	-0.06*** (0.011)	-0.03 (0.028)	-0.02 (0.021)	-0.02 (0.016)
Education or training	0.00 (0.021)	0.03 (0.032)	0.26*** (0.020)	0.10*** (0.032)	-0.02 (0.050)
Occupation dummies	x	x	x	x	x
Industry dummies	x	x	x	x	x
Country dummies	x	x	x	x	x
Constant	-1.32*** (0.129)	-0.77*** (0.208)	-1.26*** (0.189)	-1.64*** (0.144)	2.14*** (0.141)
<b>Observations</b>	<b>42 392</b>	<b>42 392</b>	<b>42 319</b>	<b>42 311</b>	<b>29 267</b>

NB: Estimates of probit multivariate regression models. Robust standard errors in parentheses, clustered by country; \*\*\* p<0.01, \*\* p<0.05, \* p<0.1.

Description of the derivation methodology of the job-skill requirements and work organisation indices is available in Annex 3. The overskilled variable is only available for the online ESJS2 sample. Weighted data.

Source: Cedefop second European skills and jobs survey, 2021.

Table 8. Labour market outcomes by type of skill mismatch, EU+, 2021

Skill mismatch	% above national median net monthly pay	% satisfied with job	% chance of losing job
Overqualified	49%	58%	44%
Overskilled	49%	55%	47%
Real overqualified	41%	50%	49%
Genuinely overqualified	42%	39%	51%
Skill gap	60%	66%	43%
Well matched	68%	75%	33%

Source: Cedefop second European skills and jobs survey, 2021.

#### 5.4. Labour market outcomes of skill mismatch

The significant costs of skill mismatch for individuals, firms and economies have been well documented (Cedefop, 2010; Quintini, 2011; Pouliakas, 2012; Cultera et al., 2022). Many international studies have found that overqualified and overskilled workers face wage and job satisfaction penalties (McGuinness, 2006; Leuven and Oosterbeek, 2011). What is still under debate is the relative magnitude and productivity consequences of different types of labour market mismatch. Better evidence would help shape skills (matching) policies and practices that prioritise targeting the costliest forms of skills mismatch (McGowan and Andrews, 2015).

McGuinness et al. (2018) used a meta-analysis of peer-reviewed articles on skills mismatch covering 40 countries to show that worker skill surpluses tend to outweigh skill gaps. Skills surpluses have non-trivial wage penalties (ranging between 7-14%). Studies exploring mismatch using longitudinal data suggest that the combination of educational mismatch and skill underutilisation is most damaging to employee outcomes (Sloane and Mavromaras, 2020).

The ESJS2 makes it possible to map the labour market outcomes of mismatch, by comparing mismatched workers with matched workers in jobs with the same educational and skill requirements. ESJS2 analysis confirms that workers whose qualifications and skills are not effectively deployed

tend to earn less and are less satisfied with their job, compared to the well matched (Table 8) <sup>(19)</sup>. They are also much more concerned with losing their job. These negative labour market outcomes are more pronounced for employees who are overqualified and overskilled, and muted for workers with skill gaps that possibly motivate them to engage in further skill development.

Overqualified EU+ workers have a 9% lower probability of receiving very high pay (above the highest quartile of the national earnings distribution) and are significantly less satisfied with their job, compared to similarly educated graduates in a matching job (Table 9). The wage penalty is larger (15% lower probability of receiving pay above the highest earnings band) among adult workers in jobs requiring an education level well below their own (severely overqualified). Relative to workers in well-suited jobs, those in jobs requiring a higher education level have a 6% higher probability of being very well-paid.

The overqualified have a higher likelihood of belonging to the highest national pay band (in the order of 1-3%, depending on the severity of mismatch) relative to matched workers in jobs with the same educational and skill requirements as their own (i.e. their work colleagues as opposed to their classmates). This implies that employers tend to offer slightly higher wages to workers with excess visible human capital. This is consistent with research based on firm-level data, which has reported a positive correlation between the share of overqualified workers and firm productivity

<sup>(19)</sup> For instance, there is a gap of 535 EUR per month between overeducated workers with tertiary education (mean=1,687 EUR) and matched workers who have the same tertiary-level education as the job requires (mean 2,222 EUR).

Table 9. Labour market outcomes of skill mismatches, EU+, 2021

Skill mismatch	Pay above highest quartile	Job satisfaction
<b>Reference group: workers with same education level (classmates)</b>		
Overqualified	-9% ***	-7% ***
Severely overqualified	-15% ***	-9% ***
Underqualified	6% ***	3% ***
<b>Reference group: workers in job with similar education and skill requirements (coworkers)</b>		
Overqualified	+1% **	-4% ***
Severely overqualified	+3% ***	-4.4% ***
Overskilled	-5% ***	-17% ***
Underqualified	-6% ***	insignificant

NB: Coefficients are obtained following estimation of Mincer-type wage regressions (Column 1) and job satisfaction regressions (Column 2). The dependent variables are dummies denoting (1) if respondents' net monthly pay is above the highest quartile of their respective national wage distribution (2) if respondents evaluate their job satisfaction with a score above seven on a 0-10 scale, where 10 is completely satisfied. A first set of regressions ['classmates'] controls for age dummies, gender, respondents' education level and a quadratic employer tenure term. In a second set ['coworkers'] the explanatory controls include age dummies, gender, a quadratic employer tenure term along with the job's required education level and an index of job-skill requirements (literacy, numeracy, interpersonal, problem-solving). Country dummies are included in all instances and standard errors are clustered by country. Marginal probabilities at the mean of all explanatory variables are reported.

Source: Cedefop second European skills and jobs survey, 2021.

(Kampelman and Rycx, 2012; McGowan and Andrews, 2015). The wage premium may reflect wage bargaining – higher salaries negotiated during the recruitment process – or employers rewarding employees with more education for higher productivity and innovation capacity (Cedefop, 2012).

Although they receive slightly higher wages, the overqualified are significantly less satisfied with their job than well-matched colleagues. Individuals with higher credentials than required are more likely to have unmet aspirations or to be disgruntled with how work is done or managed in their organisation. Such feelings of discontent are significantly more pronounced for overskilled workers, who are constrained in the use of their knowledge and skills in their job.

The labour market outcomes described above are based on analysis of cross-sectional data, making it challenging to consider skill mismatch dynamics. Results must be carefully interpreted, as differences in workers' inherent abilities and preferences are often not considered. Nevertheless, the findings demonstrate that the direction and type of skill mismatch determines its impact on workers. They illustrate that even though excess schooling may have some positive side-effects (or 'externalities') for economies, the underutilisation of skills in workplaces comes at a cost: a marked reduction in employee wellbeing. The extent of digitalisation in jobs can play an important mitigating role. Digital skill intensity in jobs, for example, partly reduces the negative wage impact of overqualification <sup>(20)</sup>.

<sup>(20)</sup> In econometric terms, there is a positive interaction between the overeducation dummy and an index of digital skill intensity. While the probability of belonging to the highest pay quartile is -8% for all overqualified workers, this is reduced by 2.6% for those in jobs with high digital skill demand.

### Key ESJS2 statistics on skill mismatch in the EU+

**38%** of EU+ workers need higher education to do their job

**42%** need medium-level qualifications



About **two-thirds** (65%) of EU+ adult workers are in jobs that broadly require their field of study



Only **45%** of EU+ adult employees can use their knowledge and skills in their main job to a great extent, showing the potential of improving skills utilisation



About **6 in 10** (63%) EU+ adult workers need to develop their knowledge and skills further to do their job better

**52%** need to improve their digital skills



The education level of **4 in 10** EU+ workers is not matched to that required by their job

**28%** of EU+ adult employees is overqualified and **12%** is underqualified



Source: Cedefop second European skills and jobs survey, 2021.

# Digital upskilling and adult learning

## 6.1. Adult learning in Europe

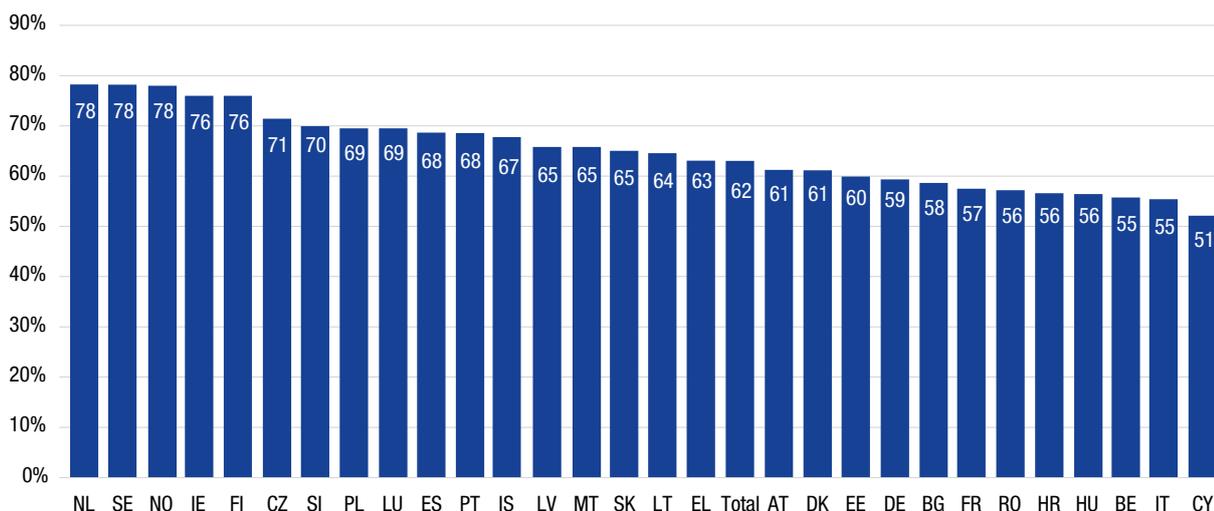
Meeting digital skill needs and mitigating skill mismatches in EU+ labour markets depends on the availability and take-up of formal, non-formal and informal continuing vocational education and training (CVET) opportunities <sup>(21)</sup>. Aside from preventing skills depreciation and sustaining the employability of workers who do not fully use their human capital, CVET is also crucial for expanding productivity. Recent research emphasises how access to high quality education and training can bridge information asymmetries between workers and organisations about the potential of new digital technologies for work, thereby easing their adoption (Jaismal et al., 2021; Alekseeva et al., 2020).

CVET is central to enabling workers to learn efficiently to use new digital technology and tools; it improves their adaptability and ability to cope with new work organisation modes. Digital innovation often goes hand-in-hand with changes in how work is done and organised: ESJS2 analysis shows that about seven in 10 (68%) EU+ workers in workplaces where new digital technologies were implemented also had to adjust to new working methods.

This chapter uses the ESJS2 to analyse to what extent European workers participate in education and training to remedy skill mismatch and to learn job-related skills in support of their professional development. The emphasis is on the (online) learning adult workers undertake to cope with new digital technology at work or to bridge digital skill gaps.

Figure 59. **Participation in formal/non-formal CVET, EU+, 2020-21**

**E\_TRAIN\***: IN THE LAST 12 MONTHS, HAVE YOU PARTICIPATED IN ANY OF THE FOLLOWING EDUCATION OR TRAINING ACTIVITIES TO LEARN NEW JOB-RELATED SKILLS? A. COURSES B. WORKSHOPS OR SEMINARS C. ON THE JOB TRAINING WITH THE SUPPORT OF A DESIGNATED TRAINER.

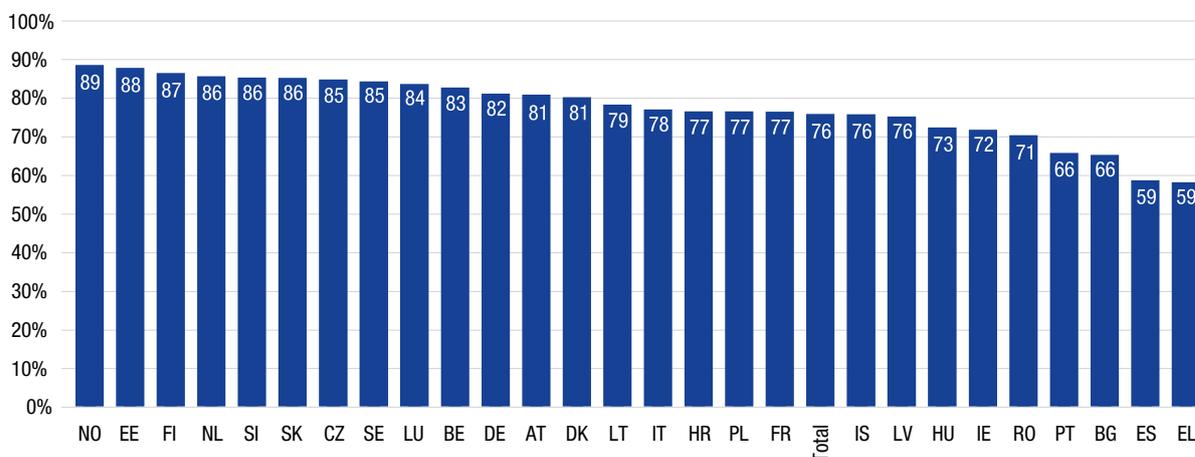


Source: Cedefop second European skills and jobs survey, 2021.

<sup>(21)</sup> In addition to supply-side policies, demand-side measures that may spur higher job-skill requirements and more efficient utilisation of skills at work are also necessary for tackling skill mismatch (Cedefop, 2015a, 2018a). This includes improved job design and work complexity achieved by more efficient managerial and organisational choices (Russo, 2017; McGuinness and Pouliakas, 2017).

Figure 60. **Employer-sponsored CVET, EU+, 2020-21**

**E TRAINPD:** WAS AT LEAST ONE OF THESE EDUCATION OR TRAINING ACTIVITIES FULLY OR PARTLY PAID BY YOUR CURRENT EMPLOYER OR DONE DURING PAID WORKING TIME?



NB: Only available for online sample and conditional on those who participated in formal/non-formal CVET in the last year; no data are available for Cyprus and Malta; weighted data.

Source: Cedefop second European skills and jobs survey, 2021.

### 6.1.1. Participation in continuing vocational education and training

Between 2020-21 around six in 10 EU+ workers (62%) took part in at least one formal or non-formal education or training activity to learn job-related skills that could improve their earnings and career opportunities in their current job or a future one (Figure 59) <sup>(22)</sup>. Educated or trained workers followed an organised course (40%), workshop or seminar (33%) or undertook structured on-the-job training with a designated teacher or trainer, such as a supervisor, foreman, colleague, consultant or other professional (40%). Participation in formal/non-formal education and training was highest in the Netherlands (78%), Sweden and Norway (both 78%) and lowest in Belgium (55%), Italy (55%) and Cyprus (51%).

Most education and training EU+ workers undertake is employer-sponsored, confirming first ESJS findings (Cedefop, 2015a, b). For three in four adult workers (76%) who participated in education or training, their current employer fully or partly paid for it or it was done during working hours (Figure 60). Adult workers benefited most often from employer-sponsored education and training in Norway (89%), Estonia (88%) and Finland (87%). Employer support to education and training was lowest among Portuguese (66%),

Bulgarian (66%), Spanish (59%) and Greek (59%) workers.

### 6.1.2. Digital skills training

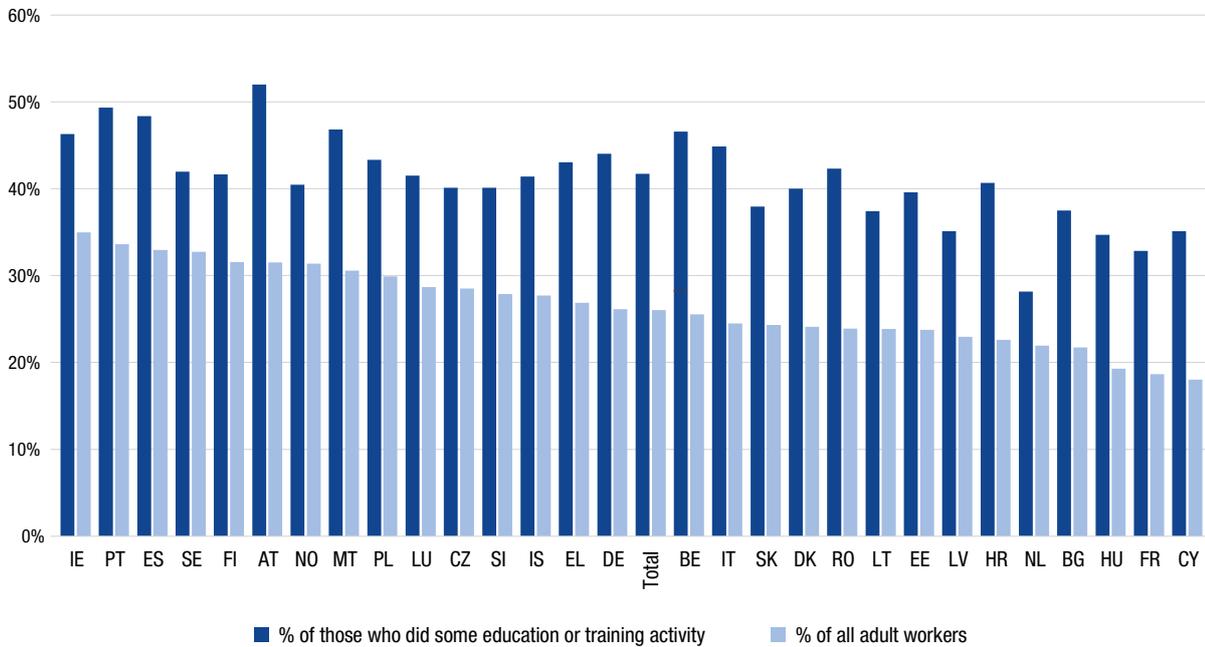
45% of European employees acknowledge that new digital technology requires knowledge and skills they currently do not possess. This mirrors the increasing emphasis on digital skills and competences in EU and national policy strategies (Cedefop, 2020c) and makes it clear that the digital transition requires a 'skills revolution' (EIT, 2022). The ESJS2 maps the extent to which education or training participation is geared towards developing digital skills for jobs and the learning tools used. The survey also captures the degree of upskilling implied by introducing new digital technology in jobs.

About one in four (26%) European adult workers (trained and non-trained ones) took part in digital skills training in 2020-21. In Ireland (35%), Portugal (34%), Spain (33%) and Sweden (33%) the share of the workforce developing digital skills is much higher. Among adult workers undertaking formal/non-formal CVET activities in the same period, about four in 10 (42%) took part in at least one such activity to develop digital skills needed in the job (Figure 61). Austria (52%), Portugal (49%) and Spain (47%) have the highest shares of adult

<sup>(22)</sup> Respondents were instructed to consider all external and internal activities, including those done online. The activities could be in process or completed, and they should also include those not paid by the individual him/herself.

Figure 61. Digital skills training, EU+, 2020-21

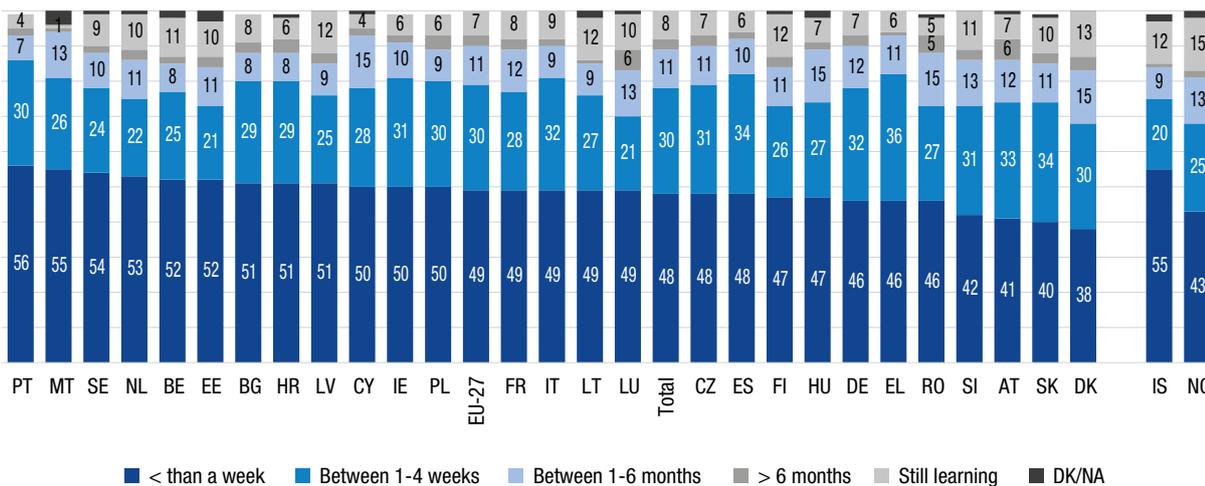
**E\_TRAINPC:** AND WAS AT LEAST ONE OF THESE EDUCATION OR TRAINING ACTIVITIES DONE TO FURTHER DEVELOP YOUR COMPUTER/IT SKILLS NEEDED FOR YOUR JOB?



Source: Cedefop second European skills and jobs survey, 2021.

Figure 62. Duration of upskilling for most used new digital technology at work, EU+, 2020-21

**E\_CHLRNFQ:** ABOUT HOW LONG DID IT TAKE YOU TO LEARN TO USE IT WELL FOR YOUR MAIN JOB? BY WELL WE MEAN WITH NO OR FEW ERRORS AND AT THE EXPECTED SPEED



Source: Cedefop second European skills and jobs survey, 2021.

workers who target digital skills improvement in at least some of their education and training. The share of adult workers prioritising digital skills in education and training in Hungary (35%), France (33%) and Cyprus (35%) is much lower.

Most EU+ workers blend formal/non-formal and informal learning to develop the skills they need to use new computer software or digital machines introduced in their workplace. Two in three employees (65%) affected by digitalisation in

2020-21 learned how to use new digital technology by interacting with their colleagues; 61% did so by participating in courses, workshops/seminars or by structured on-the-job training. 58% learned on their own (e.g. by reading books or from audio or video materials, including those available online), 45% from a supervisor/foreman and 24% from family or friends.

A lot of digital skills training in European countries cannot be considered particularly substantial. Of those who had to upskill digitally for work, half (49%) required less than a week to learn how to work proficiently with the most frequently used technology, meaning with no or few errors and at the expected speed (Figure 62). This means most digital upskilling is quite modest, typically aiming at learning how to use basic digital software or user-friendly computerised machines (e.g. digital communication platforms, handheld scanners). 30% needed less than 1 month and 22% over 1 month or are still learning how to use new technology. Digital upskilling and reskilling needs vary with the skill-intensity and specificity of new digital software or machines introduced at work. In some European countries with high digital skill training participation (e.g. Portugal, Sweden, Malta), much of it is short-duration, less complex, learning. This contrasts with the more substantial, longer duration upskilling in Austria, Slovakia and Denmark.

ESJS2 analysis signals that the main beneficiaries of digital education and training are often

not those who need it most, such as adults not using digital technology at work or those insulated from digitalisation (Table 2, Section 3.5). Males, workers with higher education and those residing in urban areas tend to benefit slightly more often from digital skills training (Table 10). Workers in temporary jobs or whose qualifications and skills are not well-matched to their job are significantly less likely to have improved their digital skills.

Digital skills training is more prevalent among those in high-skilled occupations and among adults employed in larger-sized firms. Close to one in two (46%) workers in skilled occupations took part in digital skills training in the 12 months preceding the survey, compared to 40% in semi-skilled, 33% in manual and 30% in elementary occupations. Differences in how companies in various sectors react to addressing digital skill gaps in their workforce explain why digital skills development varies across sectors. For more than six in 10 workers in the ICT sector, training focuses on digital skills. This is the case for fewer than three in 10 in the accommodation and food services sector.

One of the few encouraging findings is that older workers more often focus their education and training activities on digital skills development than younger ones.

Table 10. Digital skills training by individual/job factors, EU+, 2020-21

Individual			Job		
Gender	Female	41%	Occupation	Skilled	46%
	Male	43%		Semi-skilled	40%
Age	55-65	44%		Manual	33%
	45-54	42%		Elementary	30%
	45-44	41%	Industry	ICT	64%
	25-34	40%		Real estate	50%
Education	High	45%		Finance and insurance	49%
	Medium	39%		Water supply, sewerage, waste management	48%
	Low	38%	Education	48%	

Individual			Job		
Geography	Urban	45%	Industry	Electricity, gas, steam	44%
	Rural	38%		Professional, scientific and technical activities	44%
Contract	Temporary	38%		Administrative and support services	44%
	Permanent	42%		Public administration and defence	43%
Education mismatch	Overqualified	38%		Construction	41%
	Matched	42%		Manufacturing	40%
	Underqualified	48%		Wholesale and retail trade	40%
Skill underutilisation	Overskilled	40%		Arts, entertainment and recreation	39%
	Matched skills	44%		Transportation and storage	38%
				Other service activities	38%
				Agriculture, forestry and fishing	37%
				Mining and quarrying	31%
				Human health and social work	30%
				Accommodation and food service activities	29%
		Firm size	SME	39%	
			non-SME	44%	

NB: EU+ adult workers who undertook training to develop further the digital skills needed for their job, as % of all who participated in formal/non-formal education and training activities in last year; weighted data.

Source: Cedefop second European skills and jobs survey, 2021.

### 6.1.3. Using digital technology for learning

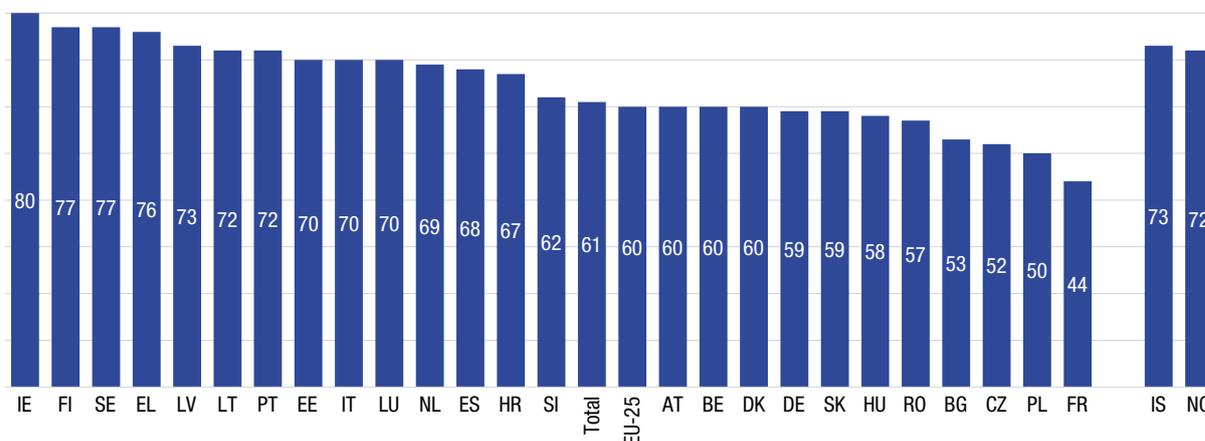
Alongside facilitating the use of digital technologies at work, the COVID-19 pandemic accelerated the use of digital technology for job-related learning. Reinforced by trends in education systems, such as the expansion of massive online open courses (MOOCs) and the proliferation of sectoral and international qualifications and – more recently – microcredentials<sup>(23)</sup>, the pandemic opened up new just-in-time and modular professional upskilling or reskilling opportunities (Castaño-Muñoz and Rodrigues 2021; Homori 2021; Cedefop, 2020b, 2021d).

Online education or training boomed during the first year of the COVID-19 crisis. More than six in 10 (61%) adult workers who participated in education or training during 2020-21 did so online at least once (Figure 63)<sup>(24)</sup>. Online education and training is most widespread in Ireland (80%), Finland (77%), Sweden (77%) and Greece (76%). In Czechia (52%), Poland (50%) and France (44%) it is much less common.

Participation in online education or training and socio-demographic characteristics are highly interrelated. Almost three in four (71%) workers in skilled occupations taking part in education or training used an online learning method or

<sup>(23)</sup> 69% of those who completed formal/non-formal education and training activities online earned at least one certificate or award. This includes officially recognised credentials issued by online learning providers and other online certificates of accomplishment (e.g. digital open badges) which demonstrate and verify learning and skills acquired online.

<sup>(24)</sup> Online learning is defined in the survey as instances where the internet is used for at least half of the instruction time of an education and training activity.

Figure 63. **Online education or training, EU+, 2020-21****E\_TRAINONL: WAS AT LEAST ONE OF THESE EDUCATION OR TRAINING ACTIVITIES MAINLY DONE ONLINE?**

NB: The base is respondents in the online sample who have followed education or training activities in the last year; no data are available for Cyprus and Malta; weighted data.

Source: Cedefop second European skills and jobs survey, 2021.

tool, compared to 59% in semi-skilled, 35% in manual and 40% in elementary occupations. Online education and training is most common for high-educated workers (73%, versus 50% and 42% of those with medium and low education, respectively). Reflecting the reality that many VET occupations require physical presence, more middle-educated general education graduates (53%) followed an online course than graduates with a vocational qualification (49%).

## 6.2. Overcoming fear of technology

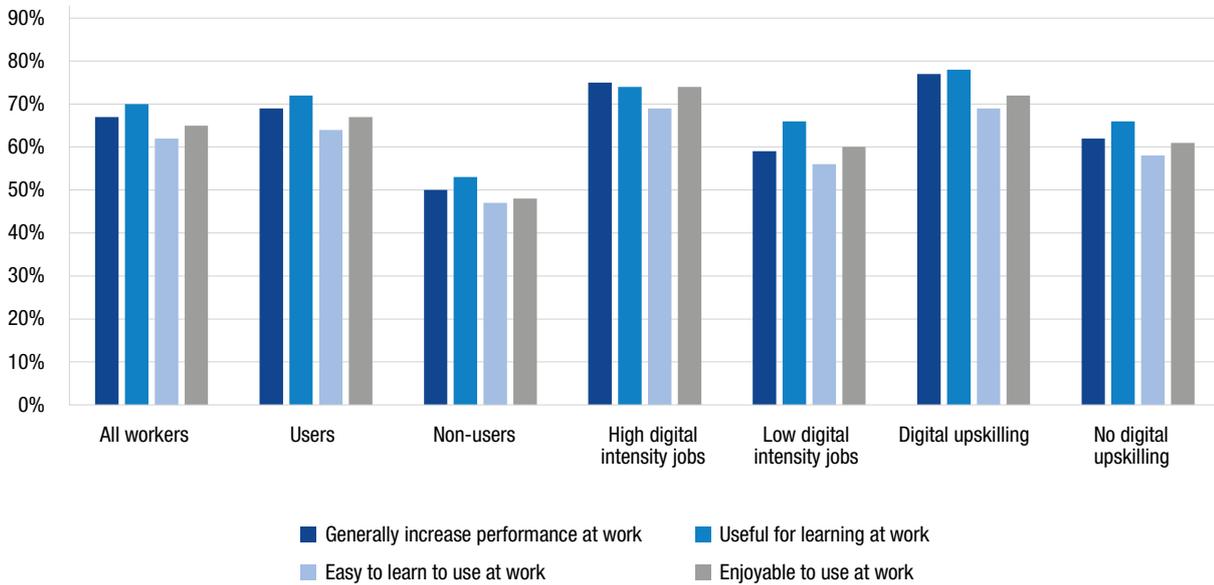
Considering the major impact of digital technology on the world of work, relatively few Europeans participate in education and training that can develop their digital skills. To boost the digital skills of the European workforce and to contribute to EU and national policy objectives, tackling inequalities in access and promoting and expanding more substantial digital skills training is important. This entails overcoming well-known and documented barriers to adult learning participation (e.g. lack of time or resources, work-life imbalance, family or care obligations, or no skill gap due to low job complexity) (Cedefop, 2020d).

A much less discussed approach to increasing workers' participation in continuing learning is turning perceived risks of being replaced by a machine or algorithm into incentives. Fear of automation influences workers' decisions to gain new professional skills (Innocenti and Golin, 2022). Some argue that workers who are more personally exposed to new digital technologies are less likely to be anxious about technological innovation (Złotowski et al., 2015; Nam, 2019). Others highlight that greater proximity to technology can aggravate concerns of its potential negative consequences and foster more negative attitudes towards it (Gnambs, 2019). What the above points to is that workers' training intentions are intermediated by prior exposure to, and acceptance of, the value of new digital technologies for work.

ESJS2 evidence shows that non-users of computer devices tend to be oblivious to higher automation risks. While 43% of those affected by technological change are in jobs that saw some job task destruction, only 4% are greatly concerned and 22% moderately concerned that new digital technologies can or will partly do some of their tasks. Such automation fears are significantly below those of computer users and are partly driven by misinformation or lack of prior exposure to technology. The finding that over seven in 10

Figure 64. **Acceptance of digital technology for work, EU+, 2021**

**D\_TAM:** TO WHAT EXTENT DO YOU AGREE WITH THE FOLLOWING STATEMENTS REGARDING THE USE OF DIGITAL OR COMPUTER TECHNOLOGIES AT WORK?



NB: The questions are asked only to respondents in the ESJS2 online sample.  
Source: [Cedefop second European skills and jobs survey](#), 2021.

non-computer-users are less likely to have used computing devices in any previous or other jobs is a case in point. A large majority of them (81%) also believe that new digital technology would only result in a small improvement in the speed or quality of their work or no improvement at all. Such findings underline that lacking awareness of the new realities of the future world of work among the most vulnerable workers is likely to distort their underlying motivation to invest in their own digital skills development.

Overcoming informational and psychological barriers to technology adoption is a key challenge also for workers with low digitally complex jobs and for those who are insulated from technological innovation in their jobs. This is evident from the finding that they tend to have significantly less favourable views about the benefits and ease of computer use than other digital users (Figure 64).

While they are not the only relevant aspects that matter for technology acceptance (Taherdoost, 2018), perceived usefulness and ease of use play an important part in individual attitudes towards adopting new technologies (Davis et al., 1989). The ESJS2 maps the acceptability of technology via four questions that measure individual attitudes towards the use of digital technology at work:

- (a) their perceived usefulness in increasing work performance;
- (b) their usefulness for learning;
- (c) how easy it is to learn to use them at work;
- (d) how enjoyable they are to use at work.

Most EU+ workers view technology positively across these four domains, with over six in 10 respondents agreeing or strongly agreeing about its value for work performance. Nevertheless, adults who use computer devices at work at a more advanced level and those affected by technological change tend to have more favourable views of technology. It is likely, therefore, that adults who are not exposed to digital technologies will be less inclined to adopt digital innovation and to invest in the upskilling or reskilling they would require.

**Key ESJS2 statistics on digital upskilling and adult learning in the EU+**

About **7 in 10** (68%) EU+ workers with newly introduced digital technologies in their workplace also experienced changes in working methods



Between 2020-21, **6 in 10** EU+ workers undertook at least one formal or non-formal education and training activity to learn job-related skills

for **76%** engaging in such activities, these were employer-sponsored



More than **6 in 10** (61%) respondents who participated in education and training activities during 2020-21, did at least one of them online



About **one quarter** (26%) of European employees participated in an education and training activity in 2020-21 geared towards the development of digital skills



Of those who had to upskill digitally for work, **half** (49%) required less than 1 week and 22% more than a month to learn how to use proficiently the most important technology in their job



Source: Cedefop second European skills and jobs survey, 2021.

## Key findings and policy pointers

At a time where the long-term impact of the 2008 global financial recession was still visible in European and global labour markets, recent crises compounded it in unprecedented ways. The disruption accompanying the COVID-19 pandemic, the Ukraine conflict, and a severe energy and cost-of-living crisis challenge citizens, workers, and enterprises. They also call into question whether established thinking about the megatrends shaping work and skills suffices in a context where economic and social volatility and uncertainty has become the new normal.

With the rapid roll-out of remote and digital communication technology for work and learning during the pandemic, digitalisation has accelerated. The digital transformation twin – the green transition – is also speeding up. Turmoil in energy markets and skyrocketing prices for conventional (carbon-based) energy sources incentivise economies to invest in renewable energy and green technology. The idea that investment in a greener future makes economic sense because the costs of not addressing the climate emergency are enormous, has gained ground. Alongside its job and labour market transformative impacts, digitalisation is also a driver of the green transition.

Understanding the scale of technological change and its impacts on European jobs and workers is essential for evidence-based policy. Mapping the digital transition, understanding what trends mean, and interpreting findings to give policy-makers the evidence they need is easier said than done. It is not possible without blending demand side indicators, such as changing skill demands, and supply aspects such as digital (and other) skills development and use in the workplace. Between and within-job dynamics, job complexity, routinisation and quality, skill mismatches, and the advantages and risks of interacting with more digital tools are other factors that must be considered. With the second European skills and jobs survey (ESJS2) Cedefop aims at strengthening the evidence base underpinning EU VET, skills,

digital and related policies. Surveying over 46 000 adult workers in 29 European countries, it takes a comparative perspective, collects up-to-date and scientifically sound information, and fills important knowledge gaps. This concluding chapter recaps the most important findings presented in this report and reflects on their implications.

### **European labour markets showed resilience during the COVID-19 pandemic, in part thanks to digital technology.**

The COVID-19 health and economic crisis brought about far-reaching changes in the world of work. Along with unprecedented public support, digital technology is also widely acknowledged as a crucial factor shielding many workers from the pandemic's negative employment effects. ESJS2 evidence confirms European labour markets were resilient during the pandemic. Two in three workers did not report changes in their employment status or working hours reductions in the COVID-19 period. At the same time, over four in 10 adult workers started using new digital technologies to perform some of their tasks. As many of their jobs could not be performed remotely, workers at the lower and middle end of the labour market were more impacted than those in skilled occupations. The share of adults in skilled occupations who worked away from their employers' premises was three times that of workers in elementary jobs.

Differences in the take-up of remote work and use of new digital technologies at work are widening digital divides in European labour markets. EU skills policy can contribute to making more lower-skilled jobs become resilient proactively, so that future health crises, social emergencies and other shocks can be managed better. This entails more systematically promoting and marketing the potential of digital technologies for sustainable work. Good practices showcasing how businesses in vulnerable sectors and occupations managed to survive the shock of the pandemic and thrived with the help of digital technology can inspire policy-makers in making labour markets and societies more resilient.

### **The digital transition primarily requires a skill-ing revolution.**

Throughout history, technological innovation has helped replace routine or dangerous work and contributed to job quality and better service provision. In the modern computer age, alongside its direct impacts, digitalisation has also drastically reduced the costs of coordinating economic activities. Some fear that this time around is different. The rapidly expanding capacity of machines to use big data for autonomous algorithmic learning and pattern recognition is seen as a threat. They could crowd out cognitive, nonroutine work previously considered out of reach of automation, or foster disruptive business models with skills downgrading in jobs. Such effects were not evident in earlier technological revolutions.

ESJS2 evidence suggests that, for most European workers affected by digitalisation, digital transformation implies task content redesign rather than job displacement. Workers experiencing digital change were more likely to be employed in workplaces with growing employment during the first year of the pandemic, rather than abrupt automation and job destruction. For only 4% of adult workers who had to upskill digitally, digital technology destroyed some of their job tasks. Many more (31%) took on new tasks in their job, often alongside some other activities phasing out. Such dynamic job-task reallocation is apparent not only for workers with occupations requiring manual

skills – often claimed to be most susceptible to machine substitution – but also common at the lower end of the labour market.

The extent to which digital technological change affects job tasks is, therefore, not immutable. So-called technological determinism, which sees technology as a relentless job-destroying force distinct from other socioeconomic forces and policies, is not supported by the analysis. While job destruction by machines or robots will affect some labour market segments, the evidence shows digitalisation in job markets primarily requires massive upskilling and reskilling. European adult workers appear to agree with this assessment: 45% of them agree that new knowledge and skills are, and will be, required to work with new digital technologies. Those who work with computer-based machines (e.g. robots) and workers in routine and manual jobs are relatively insecure about whether their job will survive automation trends.

Rather than speculating about jobs that may or will vanish, policy-makers, social partners and other stakeholders should be concerned with a much more fundamental question: how should work be (re)designed after implementing new digital technology, to capitalise on human-machine complementarities (Parker and Grote, 2020)? Techno-centric policies not fully considering the wider social, organisational, and workplace context of digitalisation risks being one-sided and may not secure desirable and equitable outcomes for citizens, organisations, and economies.

It is not invisible or unstoppable forces, but choices made by organisations and their managers that will determine whether digital technologies will lead to job simplification and routinisation or to job enrichment. European companies, social partners, skills-ecosystem stakeholders, and individuals stand to benefit from learning more about how technology can be used to generate competitive advantage via a human-centric approach to technology implementation and job (re)design.

### Despite growing digitalisation, the level of digital skills demanded in European labour markets remains relatively modest.

ESJS2 evidence shows that digital technology does not just shape the future of work, but also most of today's jobs. Almost nine in 10 workers in Europe use some computer device at work and almost half of them saw new digital technologies introduced at their workplace in 2020-21. In the first year of the pandemic, 35% of adult workers had to learn how to use new computer software or digital machines for their job. Despite the evidence pointing towards growing digitalisation and the accelerating effect of the COVID-19 pandemic, ESJS2 analysis shows the level of digital skill demand in Europe is relatively modest. Around three in 10 jobs require only basic digital skills (e.g. web browsing, word-processing or spreadsheet tasks) and one in eight jobs needs no digital skills at all. More advanced digital activities, such as database management, programming and using AI algorithms are much less common, required in, at most, two in 10 jobs in Europe today.

In spite of the digitalisation push of the pandemic, lack of investment in digital infrastructure and slow progress in adapting to new digital working modes remains a reality in many of today's EU jobs. Better coordination between fiscal, digital, social, VET, skills and related policies and systematic skills ecosystem thinking can contribute to boosting the number of more digitally complex jobs and facilitate designing incentives that boost digital upskilling of workers.

### Digital skill gaps signal an untapped productivity potential for the European economy.

The many European adult workers using only basic digital technologies at work or none at all, often have fundamental digital skill gaps that jeopardise their employability, productivity and limit career development opportunities. According to ESJS2 evidence, between 30-40% of the EU+ adult workforce would benefit from further training in relatively basic word processing and spreadsheet skills. Many EU+ workers acknowledge this.

Half of them, including those in high-skilled occupations, think there is scope to develop their digital skills further to improve job performance.

EU digital, social, VET, skills and related policies already have a strong focus on closing digital divides. ESJS2 evidence confirms the importance of broad approaches that recognise real change does not happen with measures that take a one-size-fits-all principle as their starting point. Apart from mitigating the fundamental digital skill gaps of adult workers in jobs of (very) low digital intensity, also those exposed to technological innovation in digitally intense, high-skilled jobs can significantly benefit. Countering skills-displacing technological obsolescence and enabling workers to fully reap the benefits of new digital technology are among the most important design principles. A more systematic approach to designing and delivering CVET contributes to making workers aware of their learning and productivity potential.

### Despite widespread skill gaps, participation in digital skills education and training remains modest and those who need it most often do not do it.

Alongside national innovation systems, wage bargaining practices and product market competition, the adaptiveness of vocational education and training systems also shapes the impact of the digital revolution on employment and job quality. The digital skill gaps and the scope for also strengthening complementary skillsets the ESJS2 uncovers, along with the significant inequalities in accessing digital skills training, show how important it is to have widely accessible and effective European and national up- and reskilling policies in place.

The effectiveness of digital, VET, skills and related policy depends on the approach used to identify and bridge skill gaps. Many workers who do not use digital technologies at work report that they possess usable digital skills from other or past jobs. Despite the lower digital intensity of their jobs, a significant share of older workers invests in digital skills training.

In implementing digital, VET, skills and related policies, reaching out to workers most in need of digital skills training (prioritising lower-educated and older workers, females, people living in rural areas, or those employed in low or semi-skilled jobs and smaller-sized establishments) should be a priority. Skills identification, validation and guidance to map the (informal) digital skills of workers eases the transition to jobs that make better use of their digital skills. Overcoming information gaps resulting from lacking exposure to technology is important. Such gaps are a barrier to adult workers accepting and embracing technology and make investing in their digital skills less likely.

### Low skill demands and limited complexity in many European jobs foster skills underutilisation and hinder the digital transition.

Confirming what has been found in other research, the ESJS2 identifies that many European jobs demand a relatively low level of foundation (literacy, numeracy) and digital skills. Almost one in four adult workers (and one in two workers in low-skilled occupations) do not use any simple numerical calculations at work or have to read only basic text. A significant share of EU+ jobs are manual task intensive. Frequent problem solving – often considered a shield against automation – is relatively uncommon, except in skilled occupations.

In over half of European jobs, adults do not have discretion over how to do their tasks and work in a highly standardised work environment, carrying out mostly routine tasks. About one in 10 workers, and two in 10 in lower-skilled occupations, saw their jobs become more standardised and routine in the first year of the pandemic, many of which were asked to use more computerised machines. Workers in jobs with low skill requirements and job complexity and high routinisation are most likely to only use basic digital technologies, if at all; they are more likely to see part of their job tasks being displaced by digital technology. There is a risk the digital transition for them could become a path towards a more repetitive and less rewarding job.

Reflecting the many routine, non-complex, jobs in European labour markets, more than one in two (55%) EU+ adult workers do not fully use their skills at work. 28% have qualifications at a level exceeding what is needed to do their work (over-qualified). The ‘waste’ of human capital potential translates as large wage penalties and lowers employee wellbeing. While such vertical skill mismatches are more pronounced among the highly educated, typically affecting three in 10 workers with a tertiary qualification, they are also substantial among workers with secondary education. For some European countries the combination of vertical with horizontal mismatch accentuates adverse labour market outcomes.

Considering the pronounced and widely reported skill shortages in European companies, these mismatch findings suggest that, apart from short supply, recruitment difficulties to a considerable extent also reflect poor job quality, a lack of people-oriented HR policy and untapped job design opportunities.

Elevating skill demand and job complexity in European firms via demand side interventions is crucial to making better use of the skills European workers have. These complement supply-side measures to combat skill mismatch (e.g. better labour market intelligence, career guidance and counselling, VET provision), which – while instrumental in their own right – cannot fully overcome mismatches. To implement effective workforce innovation programmes, strengthening managerial education and training and showcasing good practice examples of human-centred job design and digital investments are essential. Evidence and policy can support businesses in aligning corporate digital and innovation strategies with skills investments and utilisation practices and help them strengthen, attain or regain competitiveness.

### Preparing for Industry 5.0

Continuing the integration of new digital technologies into the world of work, more advanced technological advances are already on the horizon. The Industry 4.0 concept originated almost a decade ago. It focused on the potential of dig-

italisation in exponentially increasing production efficiency and flexibility, putting emphasis on how the seamless combination of new robotic and AI innovations, powered by big data, with existing information technologies can make the difference. It is expected that European economies will move swiftly to Industry 5.0 (ESIR, 2022; European Commission, 2021a; Nahavandi, 2019). Policy-makers and researchers have expressed hopes that the new economic paradigm will reshape work in a human-centric way, where people collaborate with technology, rather than being replaced by it (European Commission, 2021b; Lacity and Willcoks, 2018; Aleksander, 2017). This will require a focus on technology as a means to achieve societal goals beyond efficiency, such as sustainability and worker wellbeing. The road to such a labour market and society is not predetermined. Evidence mapping current trends and future developments will remain crucial to support policy-makers in taking actions that place worker wellbeing at the core of a more human digital transition and machine age.

# References

[URLs accessed 20.10.2022]

- Acemoglu D. and Restrepo P. (2018). Modelling automation. *AEA papers and proceedings*, Vol. 108, pp. 48-53.
- Acemoglu, D. and Autor, D. (2011). Skills, tasks and technologies: implications for employment and earnings. In: Card, D. and Orley Ashenfelter (eds.). *Handbook of labor economics*, Vol. 4, Part B, Chapter 12, pp. 1043-1171.
- Acemoglu D.; Lelarge C. and Restrepo P. (2020). Competing with robots: firm-level evidence from France. *AEA papers and proceedings*, Vol. 110, pp. 383-88.
- Acemoglu, D. and Restrepo. P. (2019). Automation and new tasks: how technology displaces and reinstates labor. *Journal of Economic Perspectives*, Vol. 33, No 2, pp. 3-30.
- Acemoglu, D. and Restrepo, P. (2020). Robots and jobs: evidence from US labor markets. *Journal of Political Economy*, Vol. 128, No 6, pp. 2188-2244.
- Agasisti, T.; Johnes, G. and Paccagnella, M. (2021). Tasks, occupations and wages in OECD countries. *International Labour Review*, Vol. 160, No 1, pp.85-112.
- Aleksander, I. (2017) Partners of humans: a realistic assessment of the role of robots in the foreseeable future. *Journal of Information Technology*, Vol. 32, No 1, pp.1-9.
- Alekseeva, L. et al. (2020). *AI adoption and firm performance: management versus IT*. <http://dx.doi.org/10.2139/ssrn.3677237>
- Andries, F.; Smulders, P.G. and Dhondt, S. (2002). The use of computers among the workers in the European Union and its impact on the quality of work. *Behaviour and Information Technology*, Vol. 21, No 6, pp.441-447.
- Antonczyk, D.; Fitzenberger, B. and Leuschner, U. (2009). *Can a task-based approach explain the recent changes in the German wage structure?* ZEW Discussion Papers, No 08-132. <https://www.zew.de/publikationen/can-a-task-based-approach-explain-the-recent-changes-in-the-german-wage-structure>
- Arntz, M.; Gregory, T. and Zierahn, U. (2017). Revisiting the risk of automation. *Economics Letters*, Vol. 159, pp.157-160.
- Autor, D.H. (2013). The task approach to labor markets: an overview. *Journal for Labour Market Research*, Vol. 46, No 3, pp.185-199.
- Autor, D.H. (2015). Why are there still so many jobs? The history and future of workplace automation. *Journal of Economic Perspectives*, Vol. 29, No 3, pp. 3-30.
- Autor, D.H.; Katz, L.F. and Krueger, A.B. (1998). Computing inequality: have computers changed the labor market? *Quarterly Journal of Economics*, Vol. 113, pp. 1169-1213.
- Autor, D.H.; Levy, F. and Murnane, R.J. (2003). The skill content of recent technological change: an empirical exploration. *Quarterly Journal of Economics*, Vol. 118, No 4, pp. 1279-1334.
- Autor, D.H. and Handel, M. (2013). Putting tasks to the test: human capital, job tasks, and wages. *Journal of Labor Economics*, Vol. 31, No 2, pp. 59-96.
- Baiocco, S. et al. (2022). *The algorithmic management of work and its implications in different contexts*. JRC technical papers. [https://joint-research-centre.ec.europa.eu/publications/algorithmic-management-work-and-its-implications-different-contexts\\_en](https://joint-research-centre.ec.europa.eu/publications/algorithmic-management-work-and-its-implications-different-contexts_en)
- Balsmeier, B. and Woerter, M. (2019). Is this time different? How digitalization influences job creation and destruction. *Research policy*, Vol. 48, No 8, p. 103765.
- Barley, S.R. (2015). Why the internet makes buying a car less loathsome: how technologies change role relations. *Academy of Management Discoveries*, Vol. 1, pp. 31-60.
- Barrero, J.M.; Bloom, N. and Davis, S.J. (2021). *Why working from home will stick*. NBER Working Paper, No 28731. <https://www.nber.org/papers/w28731>

- Bazylik, S. and Gibbs, M. (2022). *How is new technology changing job design?* IZA World of Labor, No 344. <https://wol.iza.org/uploads/articles/344/pdfs/how-is-new-technology-changing-job-design.pdf>
- Benbya, H.; Davenport, T.H. and Pachidi, S. (2020). Artificial intelligence in organizations: current state and future opportunities. *MIS Quarterly Executive*, Vol. 19, No 4.
- Bessen, J. (2015). Toil and technology: Innovative technology is displacing workers to new jobs rather than replacing them entirely. *Finance and Development*, Vol. 52, No 1, pp.16-20.
- Bessen, J. (2016). *How computer automation affects occupations: technology, jobs, and skills*. Boston University School of Law. Law and Economics Working Paper, No 15-49.
- Bessen J. et al. (2020). Firm-level automation: evidence from the Netherlands. *AEA Papers and Proceedings*, Vol. 110, pp. 389–93.
- Bisello, M. et al. (2019). *How computerisation is transforming jobs: evidence from the Eurofound's European working conditions survey*. JRC technical papers. [https://joint-research-centre.ec.europa.eu/publications/how-computerisation-transforming-jobs-evidence-eurofound-european-working-conditions-survey\\_en](https://joint-research-centre.ec.europa.eu/publications/how-computerisation-transforming-jobs-evidence-eurofound-european-working-conditions-survey_en)
- Bisello, M. (2021). *A comprehensive European database of tasks indices for socio-economic research*. JRC technical papers. [https://joint-research-centre.ec.europa.eu/publications/comprehensive-european-database-tasks-indices-socio-economic-research\\_en](https://joint-research-centre.ec.europa.eu/publications/comprehensive-european-database-tasks-indices-socio-economic-research_en)
- Braverman, H. (1974). *Labor and monopoly capital: the degradation of work in the twentieth century*. New York: Monthly Review Press.
- Brown, P.; Lauder, H. and Ashton, D. (2010). *The global auction: the broken promises of education, jobs, and incomes*. Oxford: Oxford University Press.
- Brown, P.; Lloyd, C. and Souto-Otero, M. (2018). *The prospects for skills and employment in an age of digital disruption: a cautionary note*. SKOPE Research Paper, No 127. Oxford, University of Oxford. <https://files.eric.ed.gov/fulltext/ED593405.pdf>
- Brown, P. and Souto-Otero, M. (2020). The end of the credential society? An analysis of the relationship between education and the labour market using big data. *Journal of Education Policy*, Vol. 35, No 1, pp. 95-118.
- Brunello, G.; Wruuck, P. and Laurent, M. (2019). *Skill shortages and skill mismatch in Europe: a review of the literature*. EIB Working Papers, No 2019/05. Luxembourg: European Investment Bank. <https://www.eib.org/en/publications/economics-working-paper-2019-05>
- Brun-Schammé, A. and Rey, M. (2021). *A new approach to skills mismatch*. OECD Productivity Papers, No 2021-24. Paris: OECD Publishing. <https://doi.org/10.1787/e9563c2a-en>
- Brynjolfsson, E. and McAfee, A. (2014). *The second machine age: work, progress, and prosperity in a time of brilliant technologies*. New York: WW Norton.
- Brynjolfsson, E.; Mitchell, T. and Rock D. (2018). What can machines learn, and what does it mean for occupations and the economy? *AEA Papers and Proceedings*, Vol. 108, pp. 43-47.
- Bughin, J. (2017). The best response to digital disruption. *MIT Sloan management review*, Vol. 58, No 4, pp.80-86.
- Busemeyer, M.R. et al. (2022). Preferred policy responses to technological change: survey evidence from OECD countries. *Socio-Economic Review*, March 2022. <https://doi.org/10.1093/ser/mwac015>
- Business Europe (2019). *Reducing labour shortages by improving skills matching: employer statement*. [https://www.buinessurope.eu/sites/buseur/files/media/position\\_papers/social/2019-09-12\\_joint\\_statement\\_labour\\_shortages\\_and\\_skills\\_mismatches.pdf](https://www.buinessurope.eu/sites/buseur/files/media/position_papers/social/2019-09-12_joint_statement_labour_shortages_and_skills_mismatches.pdf)
- Cascio, W.F. and Montealegre, R. (2016). How technology is changing work and organizations. *Annual Review of Organizational Psychology and Organizational Behavior*, Vol. 3, pp. 349-375.
- Castañó-Muñoz, J. and Rodrigues, M. (2021). Open to MOOCs? Evidence of their impact on labour market outcomes. *Computers and Education*, Vol. 173, p.1-13.
- Cedefop (2010). *The skill matching challenge: analysing skill mismatch and policy implications*. Luxembourg: Publications Office. <https://data.europa.eu/doi/10.2801/23851>

- Cedefop (2012). *Skill mismatch: the role of the enterprise*. Luxembourg: Publications Office. Cedefop research paper, No 21. <https://www.cedefop.europa.eu/en/publications/5521>
- Cedefop (2015a). *Skills, qualifications and jobs in the EU: the making of a perfect match? Evidence from Cedefops European skills and jobs survey*. Luxembourg: Publications Office. Cedefop reference series, No 103. <https://data.europa.eu/doi/10.2801/606129>
- Cedefop (2015b). *Job-related adult learning and continuing vocational training in Europe: a statistical picture*. Luxembourg: Publications Office. Cedefop research paper, No 48. <http://dx.doi.org/10.2801/392276>
- Cedefop (2018a). *Insights into skill shortages and skill mismatch: learning from Cedefops European skills and jobs survey*. Luxembourg: Publications Office. Cedefop reference series, No 106. <https://data.europa.eu/doi/10.2801/645011>
- Cedefop (2018b). *Skills forecast: trends and challenges to 2030*. Luxembourg: Publications Office. Cedefop reference series, No 108. <https://data.europa.eu/doi/10.2801/626296>
- Cedefop (2020a). *Assessing the employment impact of technological change and automation: the role of employers practices*. Cedefop research paper, No 79. Luxembourg: Publications Office. <http://data.europa.eu/doi/10.2801/173340>
- Cedefop (2020b). *Developing and matching skills in the online platform economy: findings on new forms of digital work and learning from Cedefops CrowdLearn study*. Luxembourg: Publications Office. Cedefop reference paper, No 116. <http://data.europa.eu/doi/10.2801/758653>
- Cedefop (2020c). *Vocational education and training for the future of work: country thematic perspective reports*. <https://www.cedefop.europa.eu/en/country-reports/vet-future-work>
- Cedefop (2020d). *Perceptions on adult learning and continuing vocational education and training in Europe: second opinion survey: vol. 1: Member States*. Luxembourg: Publications Office. Cedefop reference series, No 117. <http://data.europa.eu/doi/10.2801/6647>
- Cedefop (2021a). *Understanding technological change and skill needs: skills surveys and skills forecasting: Cedefop practical guide 1*. Luxembourg: Publications Office. <http://data.europa.eu/doi/10.2801/212891>
- Cedefop (2021b). *Understanding technological change and skill needs: big data and artificial methods: Cedefop practical guide 2*. Luxembourg: Publications Office. <http://data.europa.eu/doi/10.2801/144881>
- Cedefop (2021c). *Understanding technological change and skill needs: technology and skills foresight: Cedefop practical guide 3*. Luxembourg: Publications Office. <http://data.europa.eu/doi/10.2801/307925>
- Cedefop (2021d). *Skill development in the platform economy: comparing microwork and online freelancing*. Luxembourg: Publications Office of the European Union. Cedefop research paper, No 81. <http://data.europa.eu/doi/10.2801/592284>
- Cedefop and Eurofound (2020). *European company survey 2019: workplace practices unlocking employee potential*. Luxembourg: Publications Office. <https://www.eurofound.europa.eu/publications/flagship-report/2020/european-company-survey-2019-workplace-practices-unlocking-employee-potential>
- Cedefop; European Commission; ETF et al. (2021). *Perspectives on policy and practice: tapping into the potential of big data for skills policy*. Luxembourg: Publications Office. <https://data.europa.eu/doi/10.2801/25160>
- Centeno, C.; Karpinski, Z. and Urzi Brancati, M.C. (2022). *Supporting policies addressing the digital skills gap*. Luxembourg: Publications Office. JRC technical report. <https://data.europa.eu/doi/10.2760/07196>
- Chang, H.J. (2010). *23 things they don't tell you about capitalism*. London: Bloomsbury.
- Cherry, G. and Vignoles, A. (2020). *What is the economic value of literacy and numeracy?* IZA World of Labor, No 229. <https://wol.iza.org/articles/what-is-economic-value-of-literacy-and-numeracy>
- Chevalier, A. and Lindley, J. (2009). *Overeducation and the skills of UK graduates*. *Statistics in society: Series A*, Vol. 172, No 2, pp. 307-337.
- Cultrera, L. et al. (2022). Educational and skills mismatches: unravelling their effects on wages across Europe. *Education Economics*. <https://doi.org/10.1080/09645292.2022.2050995>

- Dauth, W. et al. (2017). *German robots: the impact of industrial robots on workers*. IAB-Discussion Paper, No 30. Nürnberg: IAB.
- Davis, R.D.; Bagozzi, R.R. and Warshaw, P.R. (1989). User acceptance of computer technology: comparison of two theoretical models. *Management Science*, Vol. 35, No 8, pp. 982-1003.
- Delaney, J. et al. (2020). Educational expansion and overeducation of young graduates: a comparative analysis of 30 European countries. *Oxford Review of Education*, Vol. 46, No 1.
- Deming, D.J. (2017). The growing importance of social skills in the labor market. *The Quarterly Journal of Economics*, Vol. 132, No 4, pp.1593-1640.
- Deming, D.J. and Noray, K., (2020). Earnings dynamics, changing job skills, and STEM careers. *The Quarterly Journal of Economics*, Vol. 135, No 4, pp.1965-2005.
- Dhondt, S.; Kraan, K. and van Sloten, G. (2002). *Work organisation, technology and working conditions*. Luxembourg: Publications Office.
- EIT (2022). *The future of education for digital skills*. Brussels: EIT Digital. [https://www.eitdigital.eu/fileadmin/2022/ecosystem/makers-shapers/reports/EIT-Digital\\_Report\\_The-Future-of-Education-for-Digital-Skills.pdf](https://www.eitdigital.eu/fileadmin/2022/ecosystem/makers-shapers/reports/EIT-Digital_Report_The-Future-of-Education-for-Digital-Skills.pdf)
- ESIR (2022). *Industry 5.0: a transformative vision for Europe*. ESIR Policy Brief 3. DG Research and Innovation. <https://op.europa.eu/en/web/eu-law-and-publications/publication-detail/-/publication/38a-2fa08-728e-11ec-9136-01aa75ed71a1>
- ETUI (2019). *Benchmarking working Europe 2019*. <https://www.etui.org/sites/default/files/BENCHMARKING%202019%20Web%20version%20-%20Copy.pdf>
- Eurofound (2016). *What do Europeans do at work? A task-based analysis: European Jobs Monitor 2016*. Luxembourg: Publications Office of the European Union. <https://www.eurofound.europa.eu/publications/report/2016/what-do-europeans-do-at-work-a-task-based-analysis-european-jobs-monitor-2016>
- Eurofound (2020). *Living, working and COVID-19*. COVID-19 series. Luxembourg: Publications Office. <https://www.eurofound.europa.eu/publications/report/2020/living-working-and-covid-19>
- Eurofound (2021). *Living, working and COVID-19 (update April 2021): mental health and trust decline across EU as pandemic enters another year*. Luxembourg: Publications Office. <https://www.eurofound.europa.eu/publications/report/2021/living-working-and-covid-19-update-april-2021-mental-health-and-trust-decline-across-eu-as-pandemic>
- European Commission (2016). *A new skills agenda for Europe: working together to strengthen human capital, employability and competitiveness: Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions*. COM/2016/0381 final. <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX-%3A52016DC0381>
- European Commission (2020). *Communication on a European Skills Agenda for sustainable competitiveness, social fairness and resilience*. <https://ec.europa.eu/social/main.jsp?langId=en&catId=89&furtherNews=yes&newsId=9723>
- European Commission (2021a). *Industry 5.0*. [https://ec.europa.eu/info/research-and-innovation/research-area/industrial-research-and-innovation/industry-50\\_en](https://ec.europa.eu/info/research-and-innovation/research-area/industrial-research-and-innovation/industry-50_en)
- European Commission (2021b). *Proposal for a Regulation of the European Parliament and the Council laying down harmonized rules on artificial intelligence (Artificial Intelligence Act) and amending certain union legislative acts*. COM(2021) 206 final. [https://eur-lex.europa.eu/resource.html?uri=cellar:e0649735-a372-11eb-9585-01aa75ed71a1.0001.02/DOC\\_1&format=PDF](https://eur-lex.europa.eu/resource.html?uri=cellar:e0649735-a372-11eb-9585-01aa75ed71a1.0001.02/DOC_1&format=PDF)
- Fana, M. et al. (2020). *Telework, work organisation and job quality during the COVID-19 crisis: a qualitative study*. JRC technical report. Luxembourg: European Commission. [https://joint-research-centre.ec.europa.eu/publications/telework-work-organisation-and-job-quality-during-covid-19-crisis-qualitative-study\\_en](https://joint-research-centre.ec.europa.eu/publications/telework-work-organisation-and-job-quality-during-covid-19-crisis-qualitative-study_en)
- Fernández-Macias, E. and Hurley, J. (2017). Routine-biased technical change and job polarization in Europe. *Socio-Economic Review*, Vol. 15, pp. 563–585.

- Fernández-Macías, E. and Bisello, M. (2022). A comprehensive taxonomy of tasks for assessing the impact of new technologies on work. *Social Indicators Research*, Vol. 159, No 2, pp.821-841.
- Ford, M. (2015). *Rise of the robots: technology and the threat of a jobless future*. New York: Basic Books.
- Ford, M. (2021). *Rule of the robots: how artificial intelligence will transform everything*. New York: Basic Books.
- Fossen, F.M. and Sorgner, A. (2022). New digital technologies and heterogeneous employment and wage dynamics in the United States: evidence from Individual-Level Data. *Technological forecasting and social change*, Vol. 175, 121381. <https://doi.org/10.1016/j.techfore.2021.121381>Get
- Frank, M.R. et al. (2019). Toward understanding the impact of artificial intelligence on labor. *Proceedings of the National Academy of Sciences*, Vol. 116, No 14, pp. 6531-6539.
- Freeman, R.B.; Ganguli, I. and Handel, M.J. (2020). Within-occupation changes dominate changes in what workers do: a shift-share decomposition, 2005-2015. *AEA Papers and Proceedings*, Vol. 110, pp. 394-99.
- Frey, C. and Osborne, M. (2017). The future of employment: how susceptible are jobs to computerisation. *Technological Forecasting & Social Change*, Vol. 114, pp. 254-280.
- Frey, C.B. (2019). *The technology trap: capital, labor, and power in the age of automation*. New Jersey: Princeton University Press.
- Genz, S.; Bellmann, L. and Matthes, B. (2019) Do German works councils counter or foster the implementation of digital technologies? *Jahrbücher für Nationalökonomie und Statistik*, Vol. 239, No 3, pp. 523-564.
- Gittleman, M.; Monaco, K. and Nestoriak, N. (2016). *The requirements of jobs: Evidence from a nationally representative survey*. NBER Working Paper, No 22218. Cambridge, MA: National Bureau of Economic Research.
- Gnambs, T. (2019). Attitudes towards emergent autonomous robots in Austria and Germany. *Elektrotechnik und Informationstechnik*, Vol.136, pp. 296-300.
- Gnambs, T. and Appel, M. (2019). Are robots becoming unpopular? Changes in attitudes towards autonomous robotic systems in Europe. *Computers in Human Behavior*, Vol. 93, pp. 53-61.
- Goos, M. (2018). The impact of technological progress on labour markets: policy challenges. *Oxford Review of Economic Policy*, Vol. 34, No 3, pp. 362-375.
- Goos, M. and Manning, A. (2007). Lousy and lovely jobs: the rising polarization of work in Britain. *Review of Economics and Statistics*, Vol. 89, pp. 118-133.
- Goos, M.; Manning, A. and Salomons, A. (2009). Job polarization in Europe. *American Economic Review*, Vol. 99, pp. 58-63.
- Goos, M.; Manning, A. and Salomons, A. (2014). Explaining job polarization: routine-biased technological change and offshoring. *American Economic Review*, Vol. 104, pp. 2509-2526.
- Green, F. (2012). Employee involvement, technology and evolution in job skills: a task based analysis. *Industrial and Labor Relations Review*, Vol. 65, No 1, pp. 35-66.
- Green, F. et al. (2013). Is job quality becoming more unequal? *Industrial and Labor Relations Review*, Vol. 66, No 4, pp. 753-784.
- Green, F. and Zhu, Y. (2010). Overqualification, job dissatisfaction and increasing dispersion in the returns to graduate education. *Oxford Economic Papers*, Vol. 62, pp. 740-763.
- Hamori, M. (2021). MOOCs at work: what induces employer support for them? *International Journal of Human Resource Management*, Vol. 32, No 20, pp. 4190-4214.
- Handel, M.J. (2003). Skills mismatch in the labour market. *Annual Review of Sociology*, Vol. 29, pp. 135-165.
- Handel, M.J. (2016). What do people do at work? A profile of US jobs from the survey of workplace skills, technology and management practices. *Journal of Labour Market Research*, Vol. 49, pp. 177-197.
- Handel, M.J. (2017). Measuring job content: skills, technology, and management practices. In: Buchanan, J. et al. (eds.). *Oxford handbook of skills and training*. Oxford: Oxford University Press, pp.92-123.

- Handel, M.J. (2020). *Job skill requirements: levels and trends*. MIT Work of the Future Working Papers, No 02-2020.
- Handel, M.J. and Hogarth, T. (2020). *Cedefop second European skills and jobs survey: background report* [unpublished].
- Hargittai, E. and Dobransky, K. (2017). Old dogs, new clicks: digital inequality in skills and uses among older adults. *Canadian Journal of Communication*, Vol. 42, No 2.
- ILO and UNESCO (2020). *The digitalization of TVET and skills systems*. Geneva: ILO.  
[https://www.ilo.org/skills/areas/skills-policies-and-systems/WCMS\\_752213/lang--en/index.htm](https://www.ilo.org/skills/areas/skills-policies-and-systems/WCMS_752213/lang--en/index.htm)
- Innocenti, S. and Golin, M. (2022). Human capital investment and perceived automation risks: evidence from 16 countries. *Journal of Economic Behavior and Organization*, Vol. 195(C), pp. 27-41.
- Jaismal, A.; Arun, C.J. and Varma, A. (2021). Rebooting employees: upskilling for artificial intelligence in multinational corporations. *The International Journal of Human Resource Management*, Vol. 33, No 6, pp. 1179-1208.
- Jöhnik, J.; Weißert, M. and Wyrski, K. (2021). Ready or not, AI comes: an interview study of organizational AI readiness factors. *Business and Information Systems Engineering*, Vol. 63, pp. 5-20.  
<https://doi.org/10.1007/s12599-020-00676-7>
- Kampelmann, S. and Rycx, F. (2012). The impact of educational mismatch on firm productivity: evidence from linked panel data. *Economics of Education Review*, Vol. 31, No 6, pp. 918-931.
- Katz, L.F. and Murphy, K.M. (1992). Changes in relative wages, 1963-1987: supply and demand factors. *Quarterly Journal of Economics*, Vol. 107, pp. 35-79.
- Kellogg, K.C.; Valentine, M.A. and An, C. (2020). Algorithms at work: the new contested terrain of control. *Academy of Management Annals*, Vol. 14, No 1, pp. 366-410.
- Kinkel, S.; Baumgartner, M. and Cherubini, E. (2022). *Prerequisites for the adoption of AI technologies in manufacturing: evidence from a worldwide sample of manufacturing companies*. Technovation, Vol. 110, 102375.
- Klenert, D.; Fernandez-Macias, E. and Antón, J.I. (2022). Do robots really destroy jobs? Evidence from Europe. *Economic and Industrial Democracy*, January 2022. <https://doi.org/10.1177/0143831X211068891>
- Koch, M.; Manuylov, I. and Smolka, M. (2021). Robots and firms. *The Economic Journal*, Vol. 131, No 638, pp. 2553-2584. <https://doi.org/10.1093/ej/ueab009>
- Korpi, T. (2021). *Skill mismatch in Europe: educational attainment, educational expansion and skill utilization*. Technequality deliverable D3.4. <https://technequality-project.eu/files/d34fdchangingeducationssystemsv3017-12-2021pdf>
- Lacity, M. and Willcocks, L. (2018). *Robotic and cognitive automation: the next phase*. Stratford: SB Publishing.
- Leuven, E. and Oosterbeek, H. (2011). Overeducation and mismatch in the labor market. In: Hanushek, E. and Welch, F. (eds.). *Handbook of the Economics of Education*, Elsevier Science, Vol. 4, pp. 283-326.
- Manuel, N. and Plesca, M. (2021). *Skill mismatch one year into the COVID19 pandemic*. [https://alumni.uoguelph.ca/sites/default/files/Plesca\\_Skill\\_Mismatch\\_One\\_Year\\_Into\\_the\\_COVID19\\_Pandemic.pdf](https://alumni.uoguelph.ca/sites/default/files/Plesca_Skill_Mismatch_One_Year_Into_the_COVID19_Pandemic.pdf)
- Matthes, B. et al. (2014). Collecting information on job tasks – an instrument to measure tasks required at the workplace in a multi-topic survey. *Journal for Labor Market Research*, Vol. 47, No 4, pp. 273-297.
- Mavromaras, K. et al. (2013a). The effect of overskilling dynamics on wages. *Education Economics*, Vol. 21, No 3, pp. 281-303.
- Mavromaras, K. et al. (2013b). Job mismatches and labour market outcomes: panel evidence on university graduates. *Economic Record*, Vol. 89, No 286, pp. 382-395. <https://onlinelibrary.wiley.com/doi/10.1111/1475-4932.12054>
- McGowan, A.M. and Andrews, D. (2015). *Labour market mismatch and labour productivity: evidence from PIAAC data*. OECD Economics Department Working Papers, No 1209.
- McGuinness, S. (2006). Overeducation in the labour market. *Journal of Economic Surveys*, Vol. 20, No 3, pp. 387-418.

- McGuinness, S. and Pouliakas, K. (2017). Deconstructing theories of overeducation in Europe: a wage decomposition approach. In: Polachek, S.W. et al. (2017). *Skill mismatch in labor markets*. Research in Labor Economics, Vol. 45, pp. 81-127.
- McGuinness, S.; Pouliakas, K. and Redmond, P. (2018). Skills mismatch: concepts, measurement and policy approaches. *Journal of Economic Surveys*, Vol. 32, No 4, pp. 985-1015.
- McGuinness, S.; Pouliakas, K. and Redmond, P. (2021). Skills-displacing technological change and its impact on jobs: challenging technological alarmism? *Economics of Innovation and New Technology*, <https://www.tandfonline.com/doi/full/10.1080/10438599.2021.1919517>
- Menon, S.; Salvatori, A. and Zwysen, W. (2020). The effect of computer use on work discretion and work intensity: evidence from Europe. *British Journal of Industrial Relations*, Vol. 58, No 4, pp.1004-1038.
- Milkman, R. and Pullman, C. (1991). Technological change in an auto assembly plant: the impact on workers tasks and skills. *Work and Occupations*, Vol. 18, No 2, pp.123-147.
- Miller, A.R. et al. (1980). *Work, jobs, and occupations: a critical review of the dictionary of occupational titles*. National Academies Press.
- Moss, P.I. and Tilly, C. (2001). *Stories employers tell*. New York: Russell Sage.
- Nahavandi, S. (2019). Industry 5.0: a human-centric solution. *Sustainability*, Vol. 11, No 16, pp. 4371.
- Nam, T. (2019). Citizen attitudes about job replacement by robotic automation. *Futures*, Vol. 109, pp. 39-49. <https://doi.org/10.1016/j.futures.2019.04.005>
- Nedelkoska, L. and Quintini, G. (2018). *Automation, skills use and training*. OECD social, employment and migration working papers, No 202.
- Non, M.; Dinkova, M. and Dahmen, B. (2021). *Skill up or get left behind? Digital skills and labor market outcomes in the Netherlands*. CPD discussion paper, No 419. CPB Netherlands Bureau for Economic Policy Analysis.
- OECD (2013). *OECD skills outlook 2013: first results from the survey of adult skills*. Paris: OECD publishing.
- OECD (2021a) *What happened to jobs at high risk of automation?* Policy Brief on the Future of Work. Paris: OECD publishing.
- OECD (2021b). *OECD skills outlook 2021*. Paris: OECD publishing.
- Oesch, D. and Piccitto, G. (2019). The polarization myth: Occupational upgrading in Germany, Spain, Sweden and the UK, 1992-2015. *Work and Occupations*, Vol. 46, No 4, pp. 441-69.
- Oldham, G.R. and Cummings, A. (2017). Employee creativity: personal and contextual factors at work. *Academy of Management Journal*, Vol. 39, No 3.
- Parker, S.K. and Grote, G. (2020). Automation, algorithms and beyond: why work design matters more than ever in a digital world. *Applied Psychology*, No 12241.
- Payne, J., (2012). Fronting up to skills utilisation: what can we learn from Scotlands skills utilisation projects? *Policy Studies*, Vol. 33, No 5, pp.419-438.
- Pizzinelli, C. and Shibata, R. (2022). *Has COVID-19 induced labor market mismatch? Evidence from the US and UK*. IMF working paper, 22/5.
- Polachek, S.W. et al. (eds) (2017). *Skill mismatch in labor markets*. Research in Labor Economics, No 45. Emerald Publishing.
- Pouliakas, K. (2012). The skill mismatch challenge in Europe. In: *Employment and Social developments in Europe 2012*, Chapter 6, pp. 351-394. <https://data.europa.eu/doi/10.2767/86080>
- Pouliakas, K. (2018). Risks posed by automation to the European labour market. In: Hogarth, T. (ed). *Economy, employment and skills: European, regional and global perspectives in an age of uncertainty*, pp. 45-75. [https://www.fondazionebrodolini.it/sites/default/files/pubblicazioni/file/q61\\_x\\_web\\_cor\\_0.pdf](https://www.fondazionebrodolini.it/sites/default/files/pubblicazioni/file/q61_x_web_cor_0.pdf)
- Pouliakas, K. (2021). *Artificial intelligence and job automation: an EU analysis using online job vacancy data*. Luxembourg: Publications Office. Cedefop working paper, No 6. <http://data.europa.eu/doi/10.2801/305373>
- Pouliakas, K. and Branka, J. (2020). *EU jobs at highest risk of Covid-19 social distancing: Is the pandemic exacerbating the labour market divide?* Luxembourg: Publications Office. Cedefop working paper, No 1.

- Pouliakas, K. and Ranieri, A. (2022). *Hybrid (solo) self-employment and upskilling: is online platform work a path towards entrepreneurship?*. IZA Discussion Paper, No 15344. Forthcoming in Handbook on Self-employment and Public Policy, Cheltenham: Edgar Publishing. <https://www.iza.org/publications/dp/15344/hybrid-soloself-employment-and-upskilling-is-online-platform-work-a-path-towards-entrepreneurship>
- Pouliakas, K. and Wruuck, P. (2022). *Corporate training and skill gaps: did COVID-19 stem EU convergence in training investments?* EIB Working Paper 2022/07, Luxembourg. <https://www.eib.org/en/publications/economics-working-paper-2022-07>
- Quintini, G. (2011). *Right for the job: over-qualified or over-skilled?* OECD Social, Employment and Migration Working Papers, No120. <https://doi.org/10.1787/1815199X>
- Rifkin, J. (2014). *The zero marginal cost society: the Internet of things: the Collaborative Commons, and the eclipse of capitalism*. New York: Palgrave Macmillan.
- Russo, G. (2017). *Skill utilization at work: opportunity and motivation*. IZA World of Labor, No 409. <https://wol.iza.org/uploads/articles/409/pdfs/skill-utilization-at-work-opportunity-and-motivation.pdf>
- Salvatori, A.; Menon, S. and Zwysen, W. (2018). *The effect of computer use on job quality: Evidence from Europe*. OECD Social, Employment and Migration Working Papers, No 200. <https://doi.org/10.1787/1815199X>
- Schwab, K. (2016). *The fourth industrial revolution*. Geneva: World Economic Forum.
- Sebastian R. and Biagi F. (2018). *The routine biased technical change hypothesis: a critical review*. JRC technical report. <https://data.europa.eu/doi/10.2760/986914>
- Sloane, P. and Mavromaras, K. (2020). *Overeducation, skill mismatches, and labor market outcomes for college graduates*. IZA World of Labor, No 88. <https://wol.iza.org/articles/overeducation-skill-mismatches-and-labor-market-outcomes-for-college-graduates>
- Sostero M. et al. (2020). *Teleworkability and the COVID-19 crisis: a new digital divide?* JRC technical report. [https://joint-research-centre.ec.europa.eu/publications/teleworkability-and-covid-19-crisis-new-digital-divide\\_en](https://joint-research-centre.ec.europa.eu/publications/teleworkability-and-covid-19-crisis-new-digital-divide_en)
- Sostero, M. and Fernández-Macías, E. (2021). *The professional lens: what online job advertisements can say about occupational task profiles*. JRC technical report. [https://joint-research-centre.ec.europa.eu/system/files/2022-04/JRC125917\\_0.pdf](https://joint-research-centre.ec.europa.eu/system/files/2022-04/JRC125917_0.pdf)
- Sostero, M. and Tolan, S. (2022). *Digital skills for all? From computer literacy to AI skills in online job ads*. JRC technical report, forthcoming.
- Souto-Otero, M.; Freebody, S. and Brown, P. (2021). *Technological change and labour substitution: can firm characteristics shelter workers against automation?* Digital Futures of Work Research Programme, WP4. <https://digitalfuturesofwork.com/wp-content/uploads/2021/02/WP04-BPSS-Tech.pdf>
- Spitz-Oener, A. (2006). Technical change, job tasks, and rising educational demands: looking outside the wage structure. *Journal of Labor Economics*, Vol. 24, No 2, pp.235-270.
- Sull, D.; Sull, C. and Zweig, B. (2022). Toxic culture is driving the great resignation. *MIT Sloan Management Review*, Vol. 63, No 2, pp. 1-9.
- Susskind, D. (2020). *A world without work: technology, automation and how we should respond*. Metropolitan books: New York.
- Taherdoost, H., (2018) A review of technology acceptance and adoption models and theories. *Procedia Manufacturing*, Vol. 22, pp.960-967.
- Tessema, M.T. et al. (2022). The great resignation: causes, consequences, and creative HR management strategies. *Journal of Human Resource and Sustainability Studies*, Vol. 10, No 1, pp.161-178.
- Van Loo, J.; Eiffe, F. and Van Houten, G. (2021). *Adapting business practices to new realities in the middle of a crisis: first findings from the COVID-19 European company survey*. Luxembourg: Publications Office. Cedefop working paper, No 5. <http://data.europa.eu/doi/10.2801/92218>
- Vandeplass, A. and Thum-Thysen, A. (2019). *Skills mismatch and productivity in the EU*. Luxembourg: Publications Office. <https://data.europa.eu/doi/10.2765/954687>

- Wajcman, J. (2006). New connections: social studies of science and technology and studies of work. *Work, Employment and Society*, Vol. 20, No 4, pp. 773-786.
- Weaver, D. (2020). Physical demands of work, exits from the workforce, and participation in disability programs. *The Rehabilitation Professional*, Vol. 28, No 1, pp. 37-46.
- WEF – World Economic Forum (2016). *The future of jobs: employment, skills and workforce strategy for the fourth industrial revolution*. [https://www3.weforum.org/docs/WEF\\_Future\\_of\\_Jobs.pdf](https://www3.weforum.org/docs/WEF_Future_of_Jobs.pdf)
- Willcocks, L. (2020). Robo-apocalypse cancelled? Reframing the automation and future of work debate. *Journal of Information Technology*, Vol. 35, No 4, pp. pp. 286-302.
- Złotowski, J.A. et al. (2015). Persistence of the uncanny valley: the influence of repeated interactions and a robots attitude on its perception. *Frontiers in Psychology*, Vol. 6, p. 883. <https://doi.org/10.3389/fpsyg.2015.00883>

ANNEX 1.

## Cedefop's ESJS2 expert working group

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Ms Glenda Quintini	OECD
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Ms Patricia Wruuck	European Investment Bank

## Cedefop's ESJS2 survey methodology

The second Cedefop European skills and jobs survey (ESJS2) project was implemented during 2018-22. The concept and main English questionnaire was originally developed by Cedefop experts Konstantinos Pouliakas and Marco Serafini between 2018-20, with the support of the ESJS2 expert working group. The project's contracting authority (KANTAR PUBLIC) provided support and expertise in developing, testing, and translating the second ESJS2, as well as carrying out the fieldwork in all countries and providing a first analysis and draft of the report <sup>(25)</sup>.

Prior to launching the main survey, robust cognitive testing and a pilot survey were carried out. The cognitive testing took place in six countries (Germany, Ireland, Greece, Spain, France and Poland) between May and June 2020. Both survey modes, (computer assisted telephone interviewing (CATI) and computer assisted web interviewing (CAWI)), were tested on 180 participants (30 in each country), with the overall aim of determining the reliability and validity of the survey questions.

The master English questionnaire was then translated into national versions using a robust TRAPD methodology and translatability assessment. Translators and adjudicators for all national questionnaire versions were selected from the contractors' expert network of linguists and researchers.

A pilot survey (around 40 interviews per country) was conducted in all participating countries between 10-24 February 2021 as a dress rehearsal for the main survey.

The data of the ESJS2 were collected among adults aged 25-64 who are in wage and salary

employment (i.e. paid employees, excluding those in self-employment and family workers), living in private households and whose usual place of residence is in a territory of each of the EU-27 Member States, Iceland and Norway <sup>(26)</sup>. The main fieldwork took place between May and August 2021. A total of 46 213 interviews (both telephone and online) were conducted.

In all countries apart from Cyprus and Malta, a dual mode design (telephone and online) was implemented. In each country 500 respondents were sampled using a probabilistic telephone sample, except for Finland, Iceland and Norway where population registers were used. The telephone interviews were complemented by online interviews (CAWI) run by reliable panel providers using a quota methodology. In Cyprus and Malta, where the panels were not sufficiently representative of the underlying population, Kantar implemented a single mode probabilistic telephone design.

The telephone survey was executed using mobile phones and landlines, both selecting a random sample from the population aged 25+ using the random digit dialling (RDD) technique <sup>(27)</sup>. The telephone sample was drawn independently of the online panel sample. For the non-probabilistic online sample, the majority of panellists were sourced from the Kantar LifePoints/ Profiles access panel. Quotas based on the adult working population aged 25 and over were set based on the Eurostat labour force survey 2019; strong quotas based on gender, age and region in each country and flexible/monitoring quotas based on proxies of individuals' skill level: education (ISCED), occupation (ISCO) and industry (NACE). Overall, 30 701

<sup>(25)</sup> The KANTAR PUBLIC team that supported the ESJS2 was comprised of Nicolas Becuwe (Senior Director and team leader), Jamie Burnett, Russel Castaneda, Tatiana Zabara, Lavinia Deaconu, Tanja Kimova, Wanda Alarcon Ferraguto and Anna Zemblicka. Professor Manuel Souto-Otero (Cardiff University) provided valuable expertise and input to the report as external scientific advisor.

<sup>(26)</sup> Given that the survey took place amid the COVID-19 pandemic (although in a period of receding confinement measures), people were considered eligible to participate in the survey if they were on a special working arrangement but still employed.

<sup>(27)</sup> Assigned number blocks based on the country numbering plan were used to generate the random (RDD) sample, ensuring full coverage of the phone-owning population. Prior to selecting the sample, based on the prefix of the number, the landline frame was stratified by region and the mobile frame by provider. Within each stratum, the active number blocks were sorted before a systematic random sample of numbers was drawn. The sample sizes by strata cell were drawn proportionate to the total generatable numbers by cell on the frame, thus ensuring an equal probability of selection design and a representative sample by geography for the landline sample and provider for the mobile sample.

responses were collected via CAWI and 15 512 via the CATI mode.

The probabilistic telephone sample surveyed for the ESJS2 ensures almost full coverage of the target population in all countries, with all phone owners/users having a non-zero probability of selection. The top up sample of online panellists helps maximise the total sample size per country, ensuring representativity of the adult employee population in demographic and skills dimensions <sup>(28)</sup>.

Table A1 shows the number of completed interviews per country and survey methodology. Sample sizes range from a minimum of about 1 000 observations in some countries (e.g. Cyprus, Denmark, Iceland, Malta) to a high of over 3 000 respondents in Germany, Spain, France, Italy and Poland. An average of about 1 600 adult workers per country was surveyed as part of the ESJS2 sample.

All necessary quality checks and controls were undertaken, including briefing sessions of local agencies and training of interviewers and preparation of survey implementation guidelines. Fieldwork and all aspects of sampling were centrally managed by the leading contracting authority; local agencies were responsible solely for implementation (contact, interviewing and coding) and field quality checks. For both telephone and online samples, a minimum of 10% of interviews were validated via 'soft' launches (e.g. live listen-ins or recordings or early quality checks). A series of logic checks and rules for consistency were applied centrally to identify any data inconsistencies, following data collection.

Weights were calculated for the final responding sample. The weights ensure the final net sample of responders matches population benchmarks. Where Kantar Public used a mixed mode approach, drawing samples from a telephone RDD frame and online access panels, weights were calculated independently for each sample before being combined. For the probability-based telephone sample a two-stage approach was used to calculate the weights. In the first stage design

**Table A1. Number of completed interviews for ESJS2 sample by country and sampling methodology**

Country	CATI achieved	CAWI achieved
Austria	500	1005
Belgium	500	1028
Bulgaria	499	1050
Cyprus	1001	.
Czechia	501	1069
Germany	500	2551
Denmark	502	503
Estonia	500	569
Greece	500	1503
Spain	500	2510
Finland	500	807
France	501	2513
Croatia	501	500
Hungary	499	1002
Ireland	498	895
Iceland	500	522
Italy	500	2500
Lithuania	500	502
Luxembourg	506	514
Latvia	501	503
Malta	1003	.
Netherlands	498	1003
Norway	503	521
Poland	500	2568
Portugal	501	1024
Romania	499	1529
Sweden	500	1006
Slovenia	499	501
Slovakia	500	503

Source: Cedefop second European skills and jobs survey, 2021.

<sup>(28)</sup> To achieve a representative sample of the population, the central project management team ensured that the following criteria were respected while conducting fieldwork: (i) five attempts made for no answer and busy numbers; (ii) at least 50% of the interviews conducted after 4 pm; (iii) Interviews carried out from Monday to Sunday; and (iv) if appointments are made, the number was recalled until the selected household member was available to respond or until the target number of interviews was reached.

weights were calculated to account for the probability of selection before the design weighted sample was calibrated to population benchmarks in the second stage. For the non-probability-based online sample weighting was done in one stage, calibrating the net sample of online responders back to known population benchmarks. The benchmark population data used to calibrate the samples was taken from the most recent European labour force survey data. The sample was weighted to match population data on gender by age, gender by educational attainment, gender by industry, gender by occupation and region.

A comprehensive comparison was made between the weighted online and telephone samples across many key survey estimates. On the vast majority, the differences were within the expected range for two independent random samples drawn from the same population. For some questions, which were mainly covering digital behaviours, the assumption was that the differences between the

online and telephone samples were mainly attributable to selection effects. For these questions, Kantar Public looked to create a composite set of metrics to weight the online sample to match the weighted telephone sample. The online sample was weighted to targets on these metrics based on the final weighted telephone sample. In this way the online sample matched the telephone sample across both the benchmark population targets.

For each country the final weighted online and telephone samples were combined to create one weight for all respondents. In the final step, this weight was adjusted so that countries with larger eligible populations have more influence (weight) on the pan European survey estimates than those with small eligible populations, reflecting differences in population size.

Validation of the ESJS2 estimates was further sought by comparing similar variables with two external sources: Eurostat's ICT survey and OECD's PIAAC.

# Derivation of main ESJS2 composite indices

Using the ESJS2 microdata, the following composite indices have been constructed for the purposes of this report:

- (a) digital skills intensity index (DSI);
- (b) job-skill requirements;
- (c) work routinisation;
- (d) job complexity.

For each of these indices, Cedefop has first selected items that could be merged to represent a broader construct of interest. It is ensured that all items are coded in a common direction that indicates higher frequency of use of the specific domains. The construct validity and internal consistency is subsequently examined using several empirical assessments of each construct, including bivariate correlations (Pearson's  $r$ ), inter-items reliability assessments (Cronbach's alpha) and factor analysis (FA) or principal components analysis (PCA). Selected correlated items are then combined to represent an overarching index, which is subsequently validated by examining its distribution across key socioeconomic variables (e.g. education, occupation) (criterion validity).

All indices are separated into groups of intensity according to the following rule: very low, if index value is below the threshold corresponding to one standard deviation (sd) below the mean; low, if index value is above the threshold corresponding to one sd below the mean and below the mean; medium, if index value is above the mean and below the threshold value corresponding to one sd above the mean; high, if index value is above the threshold value corresponding to one sd above the mean.

## A3.1. Digital skills intensity index (DSI)

The digital skills intensity index comprises two sub-components:

- (a) **quantitative digital intensity index** – captures

the intensity in use of 10 different digital activities (e.g. web browsing to system maintenance) by adding the number of different activities performed;

- (b) **qualitative digital complexity** – categorical variable that makes a judgment on the intensity of digital knowledge and skills required, based on how difficult/complex are the activities performed.

Analysis of the inter-item reliability of the quantitative index confirms that the 10 digital activities load well on one factor and a Cronbach's alpha analysis reveals that the resulting score is high ( $\alpha = 0.83$ ). The quantitative digital index, capturing the average number of digital activities carried out by each individual as part of his/her job, has subsequently been transformed into a categorical variable. This classifies individuals according to whether they carry out digital activities at a low level (0-4 activities), medium level (5-7 activities) or high level of frequency (8-10 activities).

A qualitative digital complexity variable has been derived by categorising individuals according to whether they carry out digital activities of low skills complexity (browsing the web, word-processing, using spreadsheets, preparing presentations), medium complexity (using specialised software, using macros or formulas in spreadsheets, merging or managing databases) or high complexity (programming, using AI methods, ICT system maintenance or repair).

Merging the above two sub-components using Cronbach's alpha reveals that the resulting score is high ( $\alpha = 0.90$ ), which justifies the creation of a larger construct, termed 'digital skills intensity'.

## A3.2. Job-skill requirements index

The job-skill requirements index is the compos-

ite measure of job demands along key domains: literacy, numeracy, interpersonal skills and problem-solving skills. For each of these domains specific sub-indices have been created by using the arithmetic means of the variables that comprise them<sup>(29)</sup>; the complexity of reading (three variables) and writing (three variables) tasks at work have been merged to formulate the literacy index; a numeracy index combines three variables indicating the level of complexity of mathematical operations carried out at a job; an interpersonal skills index is compiled by adding together the incidence of carrying out a series of social tasks at work (seven variables); and the problem-solving index is created by merging together two variables describing the extent of product or process innovation at work. A manual tasks index combines two variables on heavy lifting and hazardous work environments.

Empirical factor analysis (FA) shows that the manual tasks domain is distinct and does not load well on a common factor comprised of the remaining four job-skill requirement domains. Analysis of the inter-item reliability using Cronbach's alpha on the four broad sub-dimensions subsequently reveals that the resulting score is high ( $\alpha = 0.83$ ), which suggests that they are part of the same larger construct, termed 'job-skill requirements'.

### A3.3. Work routinisation and job complexity

The work routinisation and job complexity indices are derived after first examining the inter-item correlation of the following work organisation items available in the survey: task repetitiveness, following fixed procedures, choosing methods or tools, planning work activities, reacting to unexpected situations, doing varying assignments, learning new things. Two items summarising the demand for problem-solving tasks – developing or creating new or improved products or services, developing new or improved ways of working – have also been found to have high bivariate correlation with some of the work organisation variables.

Analysis using FA or Cronbach's alpha reveals that two items – task repetitiveness and following

fixed procedures – are distinct to the remaining variables and have therefore been merged independently into one 'work routinisation' index. The remaining variables have been joined into a 'job complexity' index that has high construct validity ( $\alpha = 0.74$ ).

### A3.4. Routine task intensity and job polarisation

To analyse the impact of digitalisation on jobs of different task intensity, jobs have been categorised in the ESJS2 sample according to the routine-manual-cognitive classification first proposed by Autor et al. (2003) and elaborated by Acemoglu and Autor (2011). Specifically, the indices of work routinisation, manual tasks and social tasks have been combined with an index of analytical job complexity. The latter aims to capture the degree of cognitive job-skill requirements by merging the sub-indices that summarise the level of complexity of foundation skills (literacy, numeracy) and problem-solving skills in jobs.

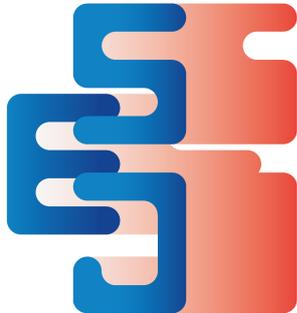
The above four sub-components have been combined in the following manner:

- (a) non-routine-cognitive (analytical): jobs with below medium routine task intensity and above medium analytical complexity;
- (b) non-routine-cognitive (interactive): jobs with below medium routine task intensity and above medium social skill demand;
- (c) non-routine-manual: jobs with below medium routine task intensity and at least some physical demands in the job;
- (d) routine-cognitive (analytical): jobs with high routine task intensity and above medium analytical complexity;
- (e) routine-cognitive (interactive): jobs with high routine task intensity and above medium social skill demand;
- (f) routine-manual: jobs with high routine task intensity and at least some physical demands in the job.

<sup>(29)</sup> In all cases, only variables that were available for the whole ESJS2 sample are used, while those that were only available for the online component of the survey were excluded.

# Acronyms

<b>AI</b>	artificial intelligence
<b>CATI</b>	computer-assisted telephone interviewing
<b>CAWI</b>	computer-assisted online (web) interviewing
<b>Cedefop</b>	European centre for the development of vocational training
<b>CNC</b>	computer numerically controlled
<b>CVET</b>	continuing vocational education and training
<b>DESI</b>	digital economy and society index
<b>DOT</b>	dictionary of occupational titles
<b>DSI</b>	digital skills intensity
<b>DTI</b>	digital skills intensity
<b>ESJS</b>	European skills and jobs survey
<b>ESJS2</b>	second European skills and jobs survey
<b>EU</b>	European Union
<b>EU-27</b>	European Union as of 1 Feb 2020, which consists of 27 countries: Belgium, Bulgaria, Czech Republic, Denmark, Germany, Estonia, Ireland, Greece, Spain, France, Croatia, Italy, Cyprus, Latvia, Lithuania, Luxembourg, Hungary, Malta, Netherlands, Austria, Poland, Portugal, Romania, Slovenia, Slovakia, Finland, Sweden
<b>EWCS</b>	European working conditions survey
<b>ICT</b>	information and communications technology
<b>ILO</b>	International labour organisation
<b>IoT</b>	internet of things
<b>ISCED</b>	international standard classification of education
<b>ISCO</b>	international standard classification of occupations
<b>MOOC</b>	massive online open course
<b>OECD</b>	Organisation for economic cooperation and development
<b>PIAAC</b>	programme for the international assessment of adult competences
<b>PLC</b>	programmable logic operators
<b>SBTC</b>	skill-biased technological change
<b>SME</b>	small and medium-sized enterprises
<b>SQL</b>	search query language
<b>STAMP</b>	skills, technologies and management practices survey
<b>VET</b>	vocational education and training
<b>WEF</b>	World economic forum



## Setting Europe on course for a human digital transition

### New evidence from Cedefop's second European skills and jobs survey

Achieving a just digital and green transition is at the heart of the European Union's policy ambitions. The COVID-19 pandemic accelerated the digital transformation, abruptly transforming the way we live, work and learn. The digital transition is all around us, but not all workers benefit equally. Many are not exposed to digital technology or are employed in low-skilled, routine and non-complex jobs. This report presents valuable evidence from Cedefop's second European skills and jobs survey (ESJS2), covering over 46 000 adult workers in 29 European countries. It illustrates the impact of the pandemic, maps the use of different types of digital technology and reflects on their implications for changing tasks, skill needs and skill mismatches. The wealth of new evidence supports the EU's digital and skills agendas and their ambitious targets. In this report Cedefop makes the case for placing worker wellbeing and quality jobs at the core of Europe's digital transition.

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