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# Rethinking education in the digital age

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## STUDY

Panel for the Future of Science and Technology

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# Rethinking education in the digital age

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The digital transformation is changing the European economy and European society. New technical and 'soft' skills are gaining in importance both in the labour market and as a means for fully participating in society. As a result, traditional roles, content and methods of education are being challenged – education today needs to prepare students for changing tasks and roles both in the labour market and as European citizens. Simultaneously, today's adults need reskilling and upskilling opportunities to enable them to tackle tomorrow's challenges.

Rethinking education in the digital age should become a central matter for today's policy-makers for two reasons. First, only education can form a skilled workforce that is prepared for future jobs and a changing labour market. Rethinking education in the digital age therefore constitutes a prerequisite for Europe's future global competitiveness. Second, only education can provide the preconditions for the social inclusion and equal participation of European citizens in a digitalised democracy. Rethinking education in the digital age therefore matters for safeguarding European values such as equality, democracy and the rule of law.

This study presents policy options on the basis of a thorough analysis of current strengths and weaknesses, as well as future opportunities and threats, for education in the digital age.

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## Executive summary

### Scope

The digital transformation of the European economy and European society more generally is fully underway. New technical and 'soft' skills are gaining in importance both in the labour market and as a means for fully participating in society. As a result, traditional roles, content and methods of education are being challenged – education today needs to prepare students for changing tasks and roles both in the labour market and as European citizens. Simultaneously, today's adults need reskilling and upskilling opportunities to enable them to tackle tomorrow's challenges.

**Rethinking education in the digital age should become a central matter for today's policy-makers for two reasons:**

- First, only education can form a skilled workforce that is prepared for future jobs and a changing labour market. Rethinking education in the digital age therefore constitutes a prerequisite for Europe's future global competitiveness.
- Second, only education can provide the preconditions for the social inclusion and equal participation of European citizens in a digitalised democracy. Rethinking education in the digital age therefore matters for safeguarding European values such as equality, democracy and the rule of law.

Education in the digital age includes but is not restricted to digital education, and encompasses the transmission of technical, 'soft' and citizenship skills, and refers to both formal and non-formal education throughout European citizens' entire lives.

This STOA study analyses the current state of play of education in the digital age across Europe, and anticipates trends and emerging issues. The study consolidates content, arguments, findings and practice deployed from the last ~10 years of literature on education in the digital age. It summarises current strengths and weaknesses, lays out upcoming opportunities and threats, and derives policy options for (European) policy-makers. As such, the study is a meta-analysis rather than providing new research in the field.

### Main results of the study

Transnational, national and sub-national policy-makers have produced a large body of policy work on digital education and education in the digital age. For approximately the last two decades, policy work has often focused on 'soft' factors such as teacher training, teacher and student competence building, as well as content development. From around 2015, policy approaches have often included 'iterative' and 'organic' approaches, i.e. small-scale experiments that can, if successful, be upscaled and mainstreamed. In terms of providing digital infrastructure, digital equipment in schools is overall at a good level across the European Union. However, large disparities between regions and countries persist. Emerging trends are the provision of platform and cloud solutions for schools, open educational resources and massive open online courses.

Students in Europe have generally high digital skills, although differences persist specifically according to educational background and country. Gender differences in skills are negligible among today's student generation, but girls remain by far less likely to turn their digital competences into a career. In the future, 'soft' and citizenship skills such as computational thinking and entrepreneurship skills should be more strongly transmitted by European schools, and career guidance will play an increasingly important role.

Educators and trainers in Europe today frequently use digital tools. However, digital applications are often not sufficiently adapted in pedagogically meaningful ways. Furthermore, the vast majority of teachers do not or only sporadically participate in professional development focused on digital

education. Teachers, moreover, often lack training and a supportive framework (including school curricula) for focusing their teaching more strongly on the 'soft' and citizenship skills urgently necessary in the digital age. At the same time, new teaching technologies could offer opportunities for personalising learning contexts, thereby improving student motivation and retention. When introducing corresponding teaching technologies, however, issues such as algorithmic discrimination and data protection will need to be discussed and solutions for them implemented.

Employers and employees increasingly operate in contexts of high work flexibility and a decreasing demand for mid-level qualifications. This influences education in the sense that today's students need to be prepared for more flexible forms of work, a possibly more flexible labour market and more mobile and dynamic work biographies. At the same time, the existing workforce will have to undergo extensive upskilling and reskilling, increasing the relevance of lifelong learning and informal and non-formal education.

Resulting from the analysis, we recommend four major policy options:

- Incorporate education in the digital age more strongly into existing and future research frameworks to further promote evidence-based policy.
- Support the creation of a knowledge-sharing platform for education in the digital age to improve the dissemination and adaption of success models across Europe.
- Simplify and harmonise the recognition and validation of lifelong learning to increase both value and quality of non-formal education, accelerate reskilling and upskilling, and better match workers' skills with the labour market's necessities.
- Offer a harmonised, yet versatile cloud solution for the provision of (open) educational resources that can be adjusted to varying contexts (e.g. different countries, educational systems).

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# 1. Introduction

Owing to the progressing digitalisation of all parts of society, an ever-increasing amount of information and knowledge is becoming almost ubiquitously available. In a time of cloud computing, blended learning, streaming and subscriptions to licenses for continuously updated software, technology and content are increasingly difficult to separate. For the field of education, defined as encompassing school education, vocational training and higher education (Cedefop, 2019b), this implies that facts no longer have to be learned by heart – instead, they can be immediately accessed using mobile devices. Much of the knowledge people had to learn by heart and retain themselves can today be stored digitally and retrieved as needed, at short notice and from almost anywhere.

Both our understanding of teaching and of the acquisition of knowledge have changed fundamentally as a result – encompassing all levels of education from early childhood to adult learning. New technologies have created the challenge to review long-term syllabi, including **learning content** for schools, universities and vocational training. Emerging forms of **self-education** have the potential to become an important pillar in the education system. These possible developments directly affect teacher education, transforming a **teacher's role** increasingly into a 'knowledge facilitator' who integrates digital technologies and methods into the educational process.

The outsourcing of information-processing and information-storage to machines also requires **increased digital competence** and **media literacy** to enable unrestricted social participation and employability. At the moment, it still remains unclear as to which new occupations will emerge in connection with software and algorithm development, data analysis, and managing, monitoring and maintaining robots and networks, and how long demand for such new occupations will last. However, there are signs that indicate a huge growth of **new types of jobs** (Dachs, 2018, p. 4) that will be created under the digitalisation paradigm (Glenn, 2016). **Facilitating young peoples' access to these jobs** through efficient learning paths and support is a **crucial task for today's policy-makers** (Katsarova & Dietrich, 2016, p. 4).

Digitalisation furthermore offers some starting points for the automated analysis and **evaluation of** (then digitalised) **learning processes** and their improvement. By means of educational data mining (EDM) and the methods of **learning analytics**, algorithms can increasingly take over the control and handling of learning processes. Thereby, personalised and particularly motivating forms of learning can be developed and teaching methods can be improved. Thus, digitalisation in the education landscape opens up new starting points for improving the quality of learning and teaching.

Digitalisation and automation, AI and machine learning increase transparency in all relevant processes of teacher education and schooling, but at the same time also enhance the importance of **privacy** issues. In a more digital educational landscape, new forms of **data misuse** and identity theft may arise, which must be addressed through technical or social innovation. This also applies to learning analytics data that raises questions about **ownership and openness of data**, as well as privacy. The challenge is to enable an appropriate usage of this data and to address the risk of misuse.

The underlying study has been structured essentially along the **three generations of digital education policies** (Conrads et al., 2017, p. 7). The first generation (until 2002) focuses mainly on **infrastructure development**, whereas in the second generation of policies (until 2010) increasingly tackles **teacher and student competence building** and training, and the third generation (since 2010) essentially is being shaped by an holistic approach, where policies increasingly aim at a **systemic integration of digital education** into the overall educational settings.

Located in a context of a complex interplay of the various issues and building on existing literature at international level, this present STOA study analyses the current state of the play of education in the digital age across Europe, and anticipates trends and emerging issues along four main stakeholder groups: policy-makers and public administration, students, educators and trainers, as well as employers and employees. The study consolidates content, arguments, findings and practice deployed from the last ~10 years of literature on education in the digital age. It summarises current strengths and weaknesses, lays out upcoming opportunities and threats, and derives policy options for (European) policy-makers.

## 2. Four main stakeholder groups in a changing world

Education is a complex system that is influenced by various social, cultural and economic factors and must integrate concepts, positions and interests of different actors. In order to elucidate the current and future challenges of education in the digital world from multiple perspectives, the literature review will be structured along the four most relevant stakeholders of education in the digital age:

- policy-makers and public administration,
- students and parents,
- educators and trainers, and
- businesses and employers.

**Policy-makers and public administration** (section 2.1) in the Member States are responsible for providing and encouraging policy frameworks especially in terms of infrastructure and investment in research and skills. EU institutions can establish networks and services that help European Member States and their citizens adapt to the changes arising from the digital transformation. This includes legal provisions for data security and privacy protection.

**Students** (section 2.2) of today are considered 'digital natives' growing up in a digitalised world. However, even though this generation uses digital devices on a daily basis, only a small part can be considered digitally fluent. The ability to use technologies in professional and academic contexts, to assess and structure information and to be critical with sources (i.e. digital literacy, digital fluency) is essential for a successful career and hence should be taught from an early age, but also in a lifelong learning process.

**Educators and trainers** (section 2.3) have a crucial role in implementing digital technologies into school life. The mere accessibility of devices, services and networks will not itself transform education. Teachers need to be trained accordingly. They should be able to identify the most suitable applications from a broad range of different options available for teaching and learning, and apply them in meaningful contexts in class.

**Businesses and employers** (section 2.4) are closely intertwined with the educational system as they require certain skills and competences taught in school, vocational training or university. For example, the demand for skills in data analysis and software development will certainly rise in the future. To avoid costs of reskilling and upskilling, school and university curricula should be adjusted to match the economy's changing needs. Furthermore, it would be beneficial to strengthen the interrelation and cooperation between entrepreneurs, education and science to increase mutual understanding and to avoid mismatches.

### 2.1. Policy-makers and public administration

Policy-makers have the responsibility of maintaining and improving the quality of education while ensuring equal access and opportunities. Policy-makers can offer a strategic vision and regulatory frameworks that coordinate actions of the affected stakeholder groups and are favourable for innovative developments.

The OECD summarises the limits and possibilities of policy-makers in the context of education in the digital age as follows: 'Governments cannot innovate in the classroom, but they can help build and communicate the case for change. Government can also play a key role as platform and broker, as stimulator and enabler' (Schleicher, 2019).

### 2.1.1. Digital education policies

Since the topics of education and digitalisation have an inherent relevance for the future (education wants to, and should, prepare for future life), policy-makers try to bring the two areas together and advance them with political programmes and a multitude of initiatives. In the following, we briefly present pertinent education policies at international level from the past 20 years.

An exhaustive overview on national approaches to digital education policies around the world is documented by the Institute for Prospective Technology Studies (IPTS), one of the Joint Research Centres of the European Commission (Conrads et al., 2017, pp. 23–25). The Joint Research Centre identified that the first generation of digital education policies (until 2002) focused mainly on **infrastructure development**, i.e. providing broadband access and technology. From around 2002 onwards, policy-makers shifted the focus towards 'soft' factors, such as **teacher training, teacher and student competence building**, as well as content development. Policy approaches after 2015 have become more 'iterative' and 'organic' and have constantly evolved into **small-scale experiments**, which, if they are successful, can be upscaled, and eventually be mainstreamed (Conrads et al., 2017, p. 7).

As one of the first studies focusing on 'soft' factors, the OECD (Haass et al., 2000) investigated in 2000 the impact of information and communication technologies (ICT) on the quality of learning and knowledge management. Around the same time, the EU Commission identified visible progress in connecting schools to the internet, but also called for further investments in the eEurope Action Plan (European Commission, 2002; European Commission, 2010; European Schoolnet, 2013). Soon after, the UNESCO adopted the 'Kronberg Declaration on the future of knowledge acquisition and sharing' (UNESCO, 2007). One of the most pertinent expectations of the responsible high-level expert group involved in the 'Kronberg Declaration' was that the **rapid development of ICT in the coming decades would revolutionise traditional educational processes** by radically changing models of knowledge acquisition, the role of teachers and trainers, as well as the institutional framework and methods of assessment. At that time, it was already expected that the ability to navigate complex systems and to find, assess, organise and use relevant information creatively would become crucial. It has also been proclaimed that learners would play an increasingly active role in acquiring and sharing knowledge, creating and disseminating content, and that teachers would increasingly act as managers of learning processes and as trainers.

Within the last two decades, national and international policy makers, actors and researchers in the education sector have increasingly articulated their demands to make use of the opportunities digitalisation offers for change towards more educational equality. Studies like the OECD's 'Education at a glance' and the reports on by the Programme for International Student Assessment (PISA) include analyses of the influence of parents' occupations, migration background, and the child's gender on educational achievements. The value of ensuring educational equity was also emphasised by its inclusion in the UN's 'Global Goals for Sustainable Development', which in turn reinforced its public perception.

In the European Union, there is a high complexity in and overlapping responsibilities for policies and programmes on digital education. The European Commission has three General Directorates working on digital education: the Directorate-General for Education and Culture (DG EAC: education, culture, youth, languages and sport), the Directorate-General Employment, Social Affairs and Inclusion (DG EMPL: adult education and vocational training) and the Directorate-General Informatics (DG DIGIT). Within the Council of the EU, the Education, Youth, Culture and Sport (EYCS) Council deals with digital education. Within the European Parliament, there are two Committees in charge of (digital) education and training issues: the Committee on Culture and Education (CULT) and the Committee on Employment and Social Affairs (EMPL).

## 2.1.2. Providing digital infrastructure

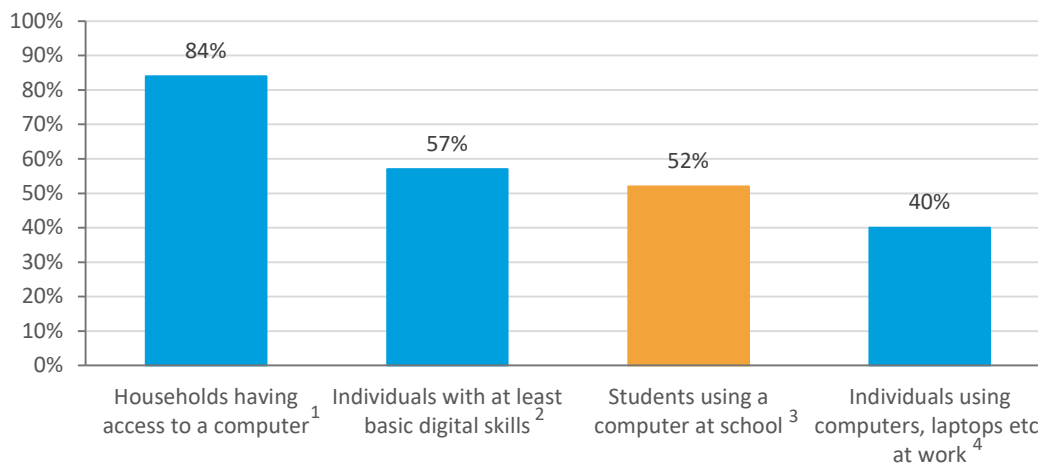
### Setting the scene

Policy-makers and public administration in the EU Member States are responsible for providing and encouraging policy frameworks especially in terms of **digital infrastructure, which lays the basis for digital education**. Access to digital infrastructure is connected to the topic of social inclusion, empowerment and justice – individuals with only limited access to digital infrastructure are easily excluded from today's digitalised society. For this reason, it is particularly important to ensure that every child, regardless of social background, has access to digital technologies at school, so that possible disadvantages can be compensated through public education. Europe's task – among others expressed in the EU's cohesion policy – is to shape the European Digital Single Market, to enhance interoperability and to overcome fragmentation. The EU can establish networks and services that help European citizens adapt to the changes arising from the digital transformation.

In terms of the current state of the play, figure 1 displays a number of key figures with regard to access to digital infrastructure across the European Union (EU-28, numbers for 2017-18). **The large majority, i.e. 84 % of households have access to a computer**. At the same time, variance between European countries is considerable: for example, 98 % of households in the Netherlands, but only 63 % of households in Bulgaria have access to a computer. Access to computers in schools also varies greatly from country to country. While 85 % of students in Luxembourg use a computer at least once a week, only 29 % in Romania have this option.

The International Computer and Information Literacy Study (ICILS) 2018 shows similarly large discrepancies between countries with regard to internet access at schools (Frailon et al., 2019, p. 41). For example, 100 % of all Danish ICT coordinators stated to have WiFi access available in their schools, whereas only 26 % in Germany did so. The ICILS average for WiFi access in schools lies at 65 %.

Figure 1 – More students use computers at school than workers at work



<sup>1</sup> Households having access to a computer via at least one of its members. Number for 2018, online code [isoc\\_ci\\_cm\\_h](#). Source: Eurostat (2019).

<sup>2</sup> Number for 2017, online code [isoc\\_sk\\_dskl\\_i](#). Source: Eurostat (2019)

<sup>3</sup> At least once a week, students at ISCED level 2, 2017-18. Source: Deloitte and Ipsos (2019a).

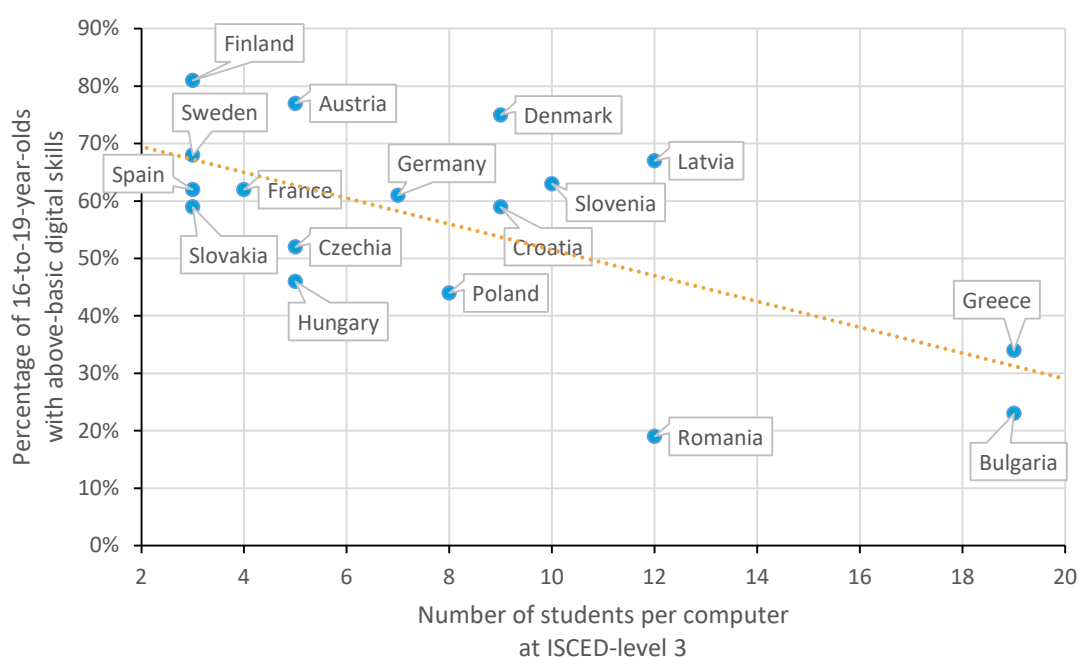
<sup>4</sup> Computers, laptops, smartphones, tablets or other portable devices. Number for 2018, online code [isoc\\_iw\\_ap](#). Source: Eurostat (2019).

## Correlation between digital equipment at school and the level of digital skills

Looking at factors that determine the level of digital skills among students, **there is empirical evidence for a close correlation between digital equipment at schools and the level of digital skills of 16- to 19-year-olds**. Figure 2 visualises this correlation across EU countries. As seen in the figure, the more computers available per student – that is, the fewer students having to share a computer – the higher the percentage of 16- to 19-year-olds<sup>1</sup> with above-basic digital skills. For example, on average three students in this age group share a computer in Sweden and 68 % of teenagers in this age group possess above-basic digital skills. On the other hand, one computer is shared by on average 19 students in this age group in Bulgaria, corresponding to a situation where only 23 % of this age group obtain above-basic digital skills. Although only a correlation, **this relationship is an indicator that education and the provision of digital tools and digital infrastructure matter for the level of young people's digital skills**.

While access to digital education infrastructure is not yet equal across all European regions and countries, data from the Programme for International Student Assessment (PISA) indicates that the 'differences in computer access between advantaged and disadvantaged students shrank between 2009 and 2012; in no country did the gap widen' (OECD, 2015).

Figure 2 – Correlation between the number of students per computer and the percentage of 16-to-19-year-olds with above-basic digital skills



Data source: Eurostat (2019), online code [isoc\\_sk\\_dsk\\_i](#); Deloitte and Ipsos (2019a). Only countries for which data on both variables is available. Own analysis.

As shown in the preceding section 2.1.1, policies on digital education have in the past 15 years shifted from a focus on infrastructure towards a focus on 'soft' factors, such as teacher training and student competence building. While the importance of 'qualitative' aspects such as teacher training and student competence building can certainly not be underestimated, sufficient infrastructure lays the basis for digital education. Given existing regional and national discrepancies between access to infrastructure and given the EU's aim to overcome 'disparities between the various regions and

<sup>1</sup> To be precise, the data refers to students at ISCED level 3 (upper secondary education), which corresponds to students in the age group of around 16- to 19-years.

the backwardness of the least-favoured regions' (1986 Single European Act, see European Commission, 2019a), helping overcome these still persisting disparities should form part of the EU's policy toolkit.

## Anticipating trends and emerging issues

### Platform and cloud solutions

In addition to the necessity of a broadly developed basic infrastructure such as broadband connectivity and computers, networks and platform solutions can take education in the digital age to the next level. Various platform business models and technical tools build on cloud computing. Cloud computing has already been broadly adopted by businesses and offers many potential applications and advantages for education.

### Open educational resources (OER)

For example, teachers can be supported in their work and teaching by openly accessible teaching content. The concept of **open educational resources (OER)** is based on the model of open access, signifying that both data and documents can be freely used by the public. This offers teachers the opportunity to access the latest teaching material, which they can use anywhere, anytime. According to a recent recommendation from UNESCO, 'the application of open licenses to educational materials introduces significant opportunities for more cost-effective creation, access, use, adaptation, redistribution, curation, and quality assurance of those materials, (...) and the creation of alternative and accessible formats of materials for learners with special educational needs' (UNESCO, 2019, p. 4).

There is an increasing deliberation and investment in OER from various countries, but this inevitably means that standards and interoperability are becoming more important (Pastor & Quirós, 2015, p. 5). In the recommendation from UNESCO, policy-makers are encouraged 'to adopt regulatory frameworks to support open licensing of publicly funded educational materials' and to develop strategies to ensure high quality of the uploaded resources (UNESCO, 2019, p. 5). **The European Union could take on the task of supporting the existing interest and efforts of individual Member States in OER by offering a common solution and/or framework.** This solution would be independent of commercial profit-oriented producers and should be designed in accordance with European applicable laws and values.

For example, **a frequently cited problem in dealing with OER is copyright.** It is the responsibility of individual content providers not to upload copyrighted material. When using OER, teachers have to comply with the different types of licenses and the corresponding rules. This complicates the application of OER and creates uncertainty among teachers. Therefore, clear legal rules concerning 'exceptions and limitations for the use of copyrighted works for educational and research purposes' (UNESCO, 2019, p. 6) should be introduced and communicated publicly.

Furthermore, the more digital technologies used in future in schools, the more student data will be generated and will require protection. Information on the protection of children and minors, personal data, and general cyber security needs to be distributed among teachers, students and parents. The European General Data Protection Regulation (European Commission, 2019d), provides a good and solid basis, but the regulation lacks specific information for the education sector, so that teachers and students often operate within grey areas when accessing OER or using other digital learning technologies.

### Massive Open Online Courses (MOOCs)

The idea behind *massive open online courses* (MOOCs) 'is to widen access and participation to everyone by removing barriers and making learning accessible, abundant, and customisable for all' (Anger et al., 2018, pp. 26–27; European Commission, 2013b; Inamorato dos Santos et al., 2016). MOOCs contain a wide variety of learning materials, which can be structured into courses and topics

and are 'made available over the internet without charge to a very large number of people' (Oxford Dictionaries, 2019b). MOOCs are considered as **affordable and versatile instruments for re- and upskilling** (Castaño-Muñoz et al., 2016), but **require personal initiative and motivation** and are therefore generally located outside the school context at the level of universities and further education.

Due to easily scalable course sizes, MOOCs are highly cost efficient for both providers and participants (Anger et al., 2018, p. 27). Since there is no admission process, access to learning opportunities for individuals from educationally and financially disadvantaged backgrounds is improved (Bughin et al., 2018, p. 64). However, recent research shows that participants with already high intellectual capital are over-represented (Bughin et al., 2018, p. 64).

A study by the Commission's Joint Research Centre (JRC) indicates that MOOC certificates have a lower value on the labour market and in subsequent formal education (Castaño-Muñoz et al., 2016). Considering the apparent advantages and the potential for lifelong learning (see section 2.4.4), policy-makers should intensify their efforts in building technical capacities, transnational solutions, and an adequate validation of digitally acquired certificates.

## 2.2. Students in a changing education system

When dealing with the question of how (future) digital education should look like, it is pivotal to consider the role of students. Students are the key recipients of (digital) education, and their school experience and thereby their professional future are shaped by today's choices. The aim of contemporary education should continue to be providing students with knowledge in different subjects and disciplines, but provide them additionally with the skills and digital competences necessary to navigate the digital world. This becomes even more important as there are to date still major differences between regions with regard to digital skills and between genders with regard to choosing ICT career paths.

This section gives an overview of students' current digital skills, enrolment in 'digital' subjects such as ICT and computer science, as well as national and gender-related differences. Furthermore, we present new skills that are highly relevant for the digital age and likely to gain importance in the future, and that tomorrow's schools should hence be prepared to teach.

### 2.2.1. Digital literacy

#### Setting the scene

While access to technology has, overall, reached high levels across the EU, new inequalities have emerged, making evident that 'equal access (...) does not imply equal opportunities' (OECD, 2015, p. 125). Growing up in a digitalised world, today's students are considered 'digital natives'. **Even though the generation of students use digital devices on a daily basis, considerable differences remain in their digital skills.** That is because there is a lot more to digital literacy than messaging or using social media. Especially individuals with socio-economically disadvantaged backgrounds lack the ability to engage with technology beneficially. PISA data shows that they spend more time online, but more likely resort to the role of passive consumers of entertainment, whereas students with higher socio-economic status use technology to create content, read the news and search for specific information deliberately (OECD, 2015, p. 135). Similarly, some students use digital technologies specifically to support learning. Video platforms, for example, offer a wide range of tutorials and explanatory videos that can be played at any time and as often as desired (Rat für kulturelle Bildung, 2019, p. 8). The significant correlation between higher computer and information literacy and the social background of students was also documented in the latest publication of ICILS – International Computer and Information Literacy Study (Fraillon et al., 2019, p. 51). This qualitative difference in the use of digital technologies – active, pedagogically beneficial



vs. passive use – is labelled the 'second' or 'second-order' digital divide (OECD, 2015, p. 125) and is a progression of the uneven distributed access-oriented 'first' digital divide.

A number of international organisations such as the OECD have forwarded the idea and emphasised the concern that **a lack in digital skills poses a threat for the students' future chances in the labour market**. The ability to use technologies in professional and academic contexts, to assess and structure information and to be critical with sources will increasingly become essential for a successful career (Butcher, 2014).

The European Parliament and the Council of the European Union have already recognised the ubiquitous importance of digital skills in 2006 by identifying digital competence as one of eight key competences essential for lifelong learning (European Parliament and the Council of the European Union, 2006). Since then, the EU has identified indicators to measure digital skills and embedded them in several Digital Competence frameworks in order to support the development of digital skills of all citizens (DigComp), educators (DigCompEdu), educational organisations (DigCompOrg) and consumers (DigCompConsumers). Four proficiency levels in five areas (information and data literacy; communication and collaboration; digital content creation; safety; problem solving) enable individuals to self-assess their digital skills and allow a comparison between Member States (Vaikutytė-Paškauskė et al., 2018, pp. 16–17).

Figure 3 displays the percentage of 16- to 19-year-olds with above-basic digital skills across European countries. As seen in the figure, Luxemburg and Finland rank highest, with 81 % of 16- to 19-year-olds having above-basic digital skills. Countries with less than one third of 16- to 19-year-olds having above-basic digital skills are Cyprus, Bulgaria and Romania.

#### Eurostat definition: Level of digital skills

The Eurostat indicator for digital skills is based on the European Digital Competence Framework (DigComp). Data on the level of digital skills is obtained by asking individuals about activities they have performed during the past three months. It is assumed that individuals having performed certain activities (e.g. sending and receiving emails, participating in social networks, seeking information online) have the corresponding skills (Eurostat 2019b).

Individuals with **above-basic digital skills** are for example individuals who have performed all of the following activities: sending/receiving emails, participating in social networks, installing software and applications, using online banking, using word processing software, using advanced spreadsheet functions to organise and analyse data such as sorting and filtering.

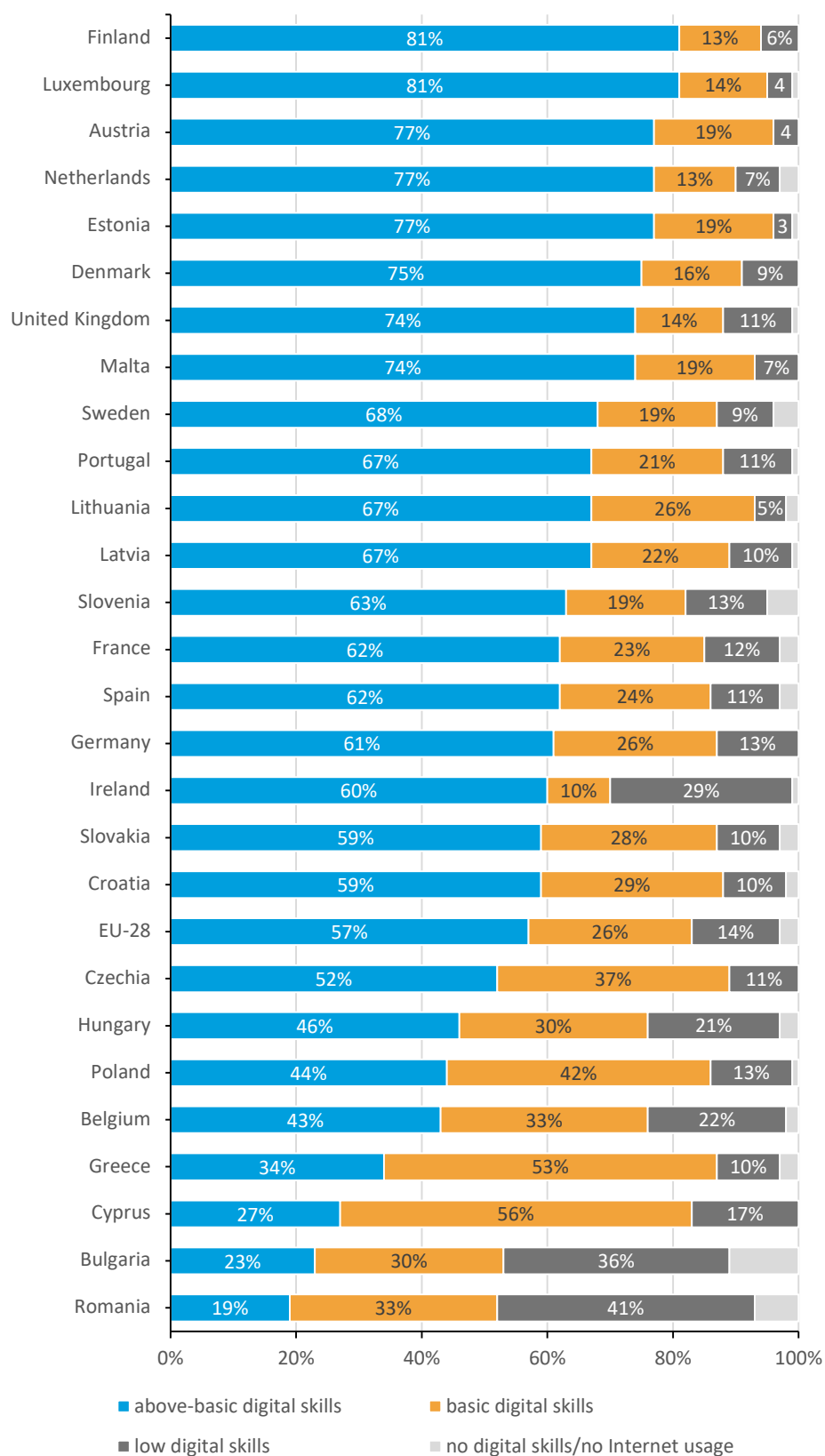
Individuals with **basic digital skills** are for example individuals who have sent/received emails, installed software and applications, and used spreadsheet software (without advanced functions such as sorting and filtering).

Individuals with **low digital skills** are for example individuals who have sent/received emails, installed software and applications, but have neither used a word processing, nor a spreadsheet software, nor have used software to edit photos, videos or audio files.

Individuals with **no digital skills** have not performed any relevant activities, despite declaring having used the internet at least once during the past three months.

For more detail on different types of digital activities and the coding scheme see Eurostat (2019b).

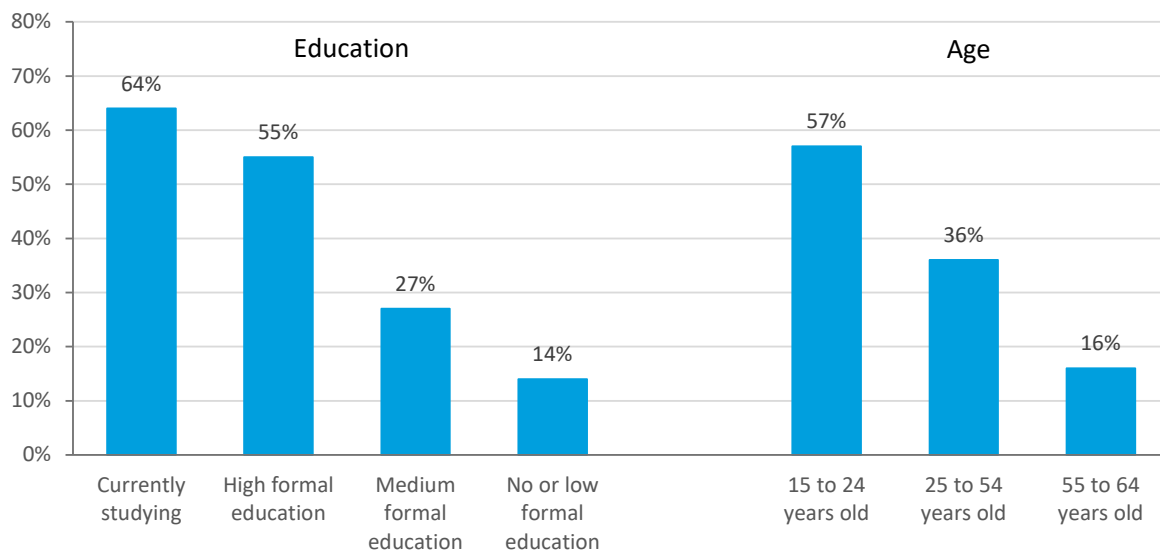
Figure 3 – Distribution of the level of digital skills across European countries



Source: Eurostat (2019), online code [isoc\\_sk\\_dskl\\_i](#); own calculations. Numbers for individuals of age 16 to 19.

In addition to regional disparities, differences exist with regard to educational background and age groups, as displayed in figure 4. With regard to education, 64 % of currently enrolled students and 55 % of individuals with high formal education have above-basic digital skills, but only 27 % with medium formal education and 14 % with no or low formal education have so. A similar divide becomes evident when looking at age groups: 57 % of individuals between 15 and 24 years have above-basic digital skills, but only 36 % of those between 25 and 54 and only 16 % of those between 55 and 64 do so.

Figure 4 – Having above-basic digital skills depends on educational background, age and gender

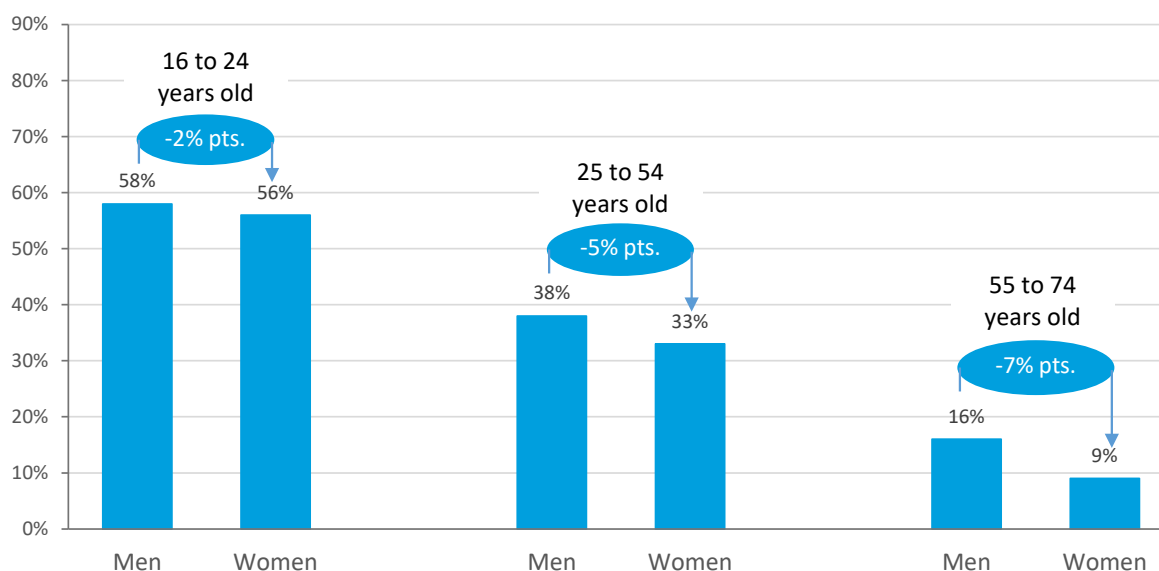


Percentage of individuals having above-basic digital skills. Source: Eurostat (2019), online code [isoc\\_sk\\_dskl\\_i](#).

### Anticipating trends and emerging issues

Digital skills are increasingly becoming pivotal for individuals' careers and for the future of Europe as a whole – as the Digital Education Plan warns, the chances are that 'Europe will lose its competitiveness if education fails to provide digital competences to Europeans of all ages' (Vaikutytė-Paškauskė et al., 2018, p. 6). With a further digitalisation of the workplace, it may become increasingly difficult to integrate older workers into the labour market – underlining the indispensability of lifelong learning (see section 2.4.4). Since the first digital divide (access to technology) was substantially reduced in the majority of Europe, the focus of future policies should lie in reducing the generation gap and disparities between different socio-economic backgrounds (Gartland, 2014, pp. 22–23). In this regard, intergenerational learning in particular offers several opportunities (Patrício & Osório, 2016). **Intergenerational learning** can manifest itself in many forms. It ensures mutual motivation, intergenerational exchange and digital inclusion. In such peer education models, younger employees introduce older ones to new technologies, while older workers in return share their domain and procedural knowledge.

Figure 5 – The gender gap with regard to digital skills is more pronounced for older generations



Percentage of individuals having above-basic digital skills, by gender and age, as well as differences between women and men (in percentage points). Source: Eurostat (2019), online code [isoc\\_sk\\_dskl\\_i](#); own calculations.

## 2.2.2. Gender-specific skills and interests

### Setting the scene

Gender-specific interests and an existing gender imbalance with regard to ICT jobs are recurring issues in the literature on digital education (e.g. European Commission, 2013c; EIGE, 2018b; EIGE, 2018a; European Commission, 2018c). A persistent theme is the observation that men have more confidence in their digital skills than women (EIGE, 2018b), are more active and more interested in digital technology (e.g. EIGE, 2018b), and are considerably more likely to take up jobs in the digital sector (e.g. European Commission, 2013c; EIGE, 2018c; European Commission, 2018c). For example, as a recent study by the European Institute for Gender Equality (EIGE) points out, **only 17% of ICT specialists in the European Union are women** (EIGE, 2018c). Women who study ICT are not only proportionally fewer than men, but are also less likely to take up jobs relating to their ICT specialist skills (referred to as the so-called 'leaky pipeline', cf. European Commission, 2013c, 2018c).

Interestingly, an original analysis based on Eurostat data shows that **women's and men's overall digital skills differ only negligibly at a young age** (figure 5). In fact, when measuring digital skills in terms of activities performed, there are both European countries where young men outperform young women and countries where young women outperform young men (compare figure 6 as well as the info box on measuring digital skills above).<sup>2</sup> Interestingly, there are more European countries with digitally underskilled young men than countries with underskilled young women. However, despite having similar levels of digital skills, women continue to have less confidence in their digital skills than men (European Commission, 2018c; cf. EIGE, 2018b).

Hence, an equal playing field in terms of digital competencies among young European women and men does not translate into an equal playing field in terms of enrolment in ICT subjects, let alone in

<sup>2</sup> The picture is the same when considering different aspects of overall digital skills, that is communication, problem solving and software skills (own analysis based on data from Eurostat 2019a).

terms of ICT jobs. As an original analysis in figure 7 shows, there is only one European country (Bulgaria) where women constitute slightly more than one third of students enrolled in ICT subjects. The EU-28 average lies at 18 %. One possible explanation for the discrepancy between a gender balance with regard to skills on the one side and enrolment in ICT subjects on the other side is the fact that **women have lower confidence in their own digital skills**.

To date, policy frameworks on digital education include references to gender-related issues. For example, the Digital Education Action Plan adopted by the European Commission suggests promoting digital and entrepreneurial competences among girls and to mobilise stakeholders (such as companies and NGOs) to equip girls with digital skills and to provide inspirational models (European Commission, 2018a). In a report by the European Parliament, the EP calls 'on the Commission and the Member States to make efficient use of funding from the European Social Fund (ESF) (...) to make those labour-market sectors where women are under-represented because of gender stereotypes more familiar and attractive to them' (European Parliament, 2012). The EP furthermore 'considers that the strategies should include positive action, lifelong learning and active encouragement for girls to undertake studies in areas which are not traditionally seen as "feminine", such as information technology' (European Parliament, 2012). However, measurable impacts of such calls, for example in terms of an increasing number of young women choosing to study ICT-related subjects, are still to be observed.

### Anticipating trends and emerging issues

With regard to future trends related to gender-specific skills and interests, three main aspects deserve specific attention, which will be set out in more detail in the following paragraphs: (1) current trends with regard to a decreasing skill gap between genders and a simultaneously remaining enrolment and occupation gap (i.e. women's lower likelihood to choose ICT-related studies and professions) are not unlikely to be perpetuated at least for the coming decades, (2) bottom-up initiatives and initiatives by private sector agents promoting the role of girls and women in the digital and tech economy are expected to increase, (3) coding and data analytics jobs could constitute a specific chance for women in the future labour market.

#### A perpetuation of the status quo: equal in skills, but not in enrolment and job decisions

As shown in the preceding paragraphs, no substantive gap between young men and women with regard to digital skills can be observed. In contrast to older generations, **today's young men and women have already reached parity when considering digital skills, which clearly constitutes an opportunity for a stronger role of women** in a constantly more digitalised labour market. At the same time, however, the gender gap with regard to ICT enrolment and occupations continues to exist, and there is little indication that this will change substantially in the near future – unless strong measures being taken both by public and private sector agents. A continuously low number of women enrolling into ICT subjects and only few women taking up ICT-related jobs constitutes a clear threat for an already extremely tight (digital) labour market.

#### Bottom-up educational initiatives to support girls and promote women in the digital economy

Various bottom-up initiatives to support girls and promote women in the digital economy can be observed and are expected to increase in the future. First, newspapers and social media increasingly publish stories on female role models in ICT and digital occupations, some of which have gone viral in the recent past.<sup>3</sup> Second, there are female-led initiatives to promote women in the digital

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<sup>3</sup> This phenomenon is not restricted to the European context. Recent international examples are a news story on 'The Secret History of Women in Coding' by Thompson (2019) and the story around researcher Katie Bouman, head of the group which developed the algorithm for imaging black holes, e.g. Ellis-Petersen (2019), Halpern (2019).

economy, for example *Women who code*<sup>4</sup>, *Fintechladies*<sup>5</sup>, *Rladies*<sup>6</sup>, *Data + Women*<sup>7</sup> and *Women in Data Science*<sup>8</sup>, to name just a few initiatives active across European countries. These are mostly professional networks organised by women for women, mainly with the aim of creating visibility, supporting and encouraging each other, and learning from each other's experience (so-called peer education). Third, there are initiatives by tech companies such as Google's *Made with Code*<sup>9</sup> or Microsoft's *DigiGirlz Day*<sup>10</sup>. In contrast to professional networks, initiatives by tech companies tend to be more strongly targeted towards girls and young professionals, probably for the reason that they at least partially function as employer branding and recruiting pipelines. Last but not least, public initiatives such as the 2016 ECWC (European Celebration of Women in Computing) Award aim at encouraging girls and women by presenting female role models in the Digital Economy.<sup>11</sup> Adaawards<sup>12</sup> is an example of a women in tech award sponsored both by private companies, interest groups such as CEPIS (Council of European Professional Informatics Societies), and a public actor, in this case the European Commission.

All the above-mentioned initiatives can be understood as educational initiatives to promote girls and women in the digital economy by creating visibility, as well as fostering skills and confidence. Unfortunately, there are to date principally no scientific evaluations of the effect of such initiatives, and of the conditions under which such initiatives have a measurable impact. The possibility exists that such initiatives mainly attract and impact girls and women already active or interested in ICT-related fields, and less so girls and women who would otherwise not have become interested in this field.

ICT jobs as professional opportunities for women and the example of bootcamps for lateral career moves

In today's tight ICT labour market, **a large portion of ICT professionals come originally from non-ICT backgrounds** (e.g. Cedefop, 2016a; Lindner, 2018), many of whom have made lateral career moves to transition to an ICT profession. To make such individuals succeed in their jobs, advanced training and professional development are of utmost importance. In the context of coding and data analytics, so-called coding bootcamps are today a common option for individuals with non-coding backgrounds to embark a coding career.<sup>13</sup> Similar options are relatively sparse for other ICT professions but could constitute a great opportunity for tackling the adamant skills shortage in ICT professions across Europe. Given that the target group of professional bootcamps are lateral career movers, **bootcamps can also constitute great opportunities for individuals re-entering the workforce, such as women after a career break**. Furthermore, as companies have great difficulties filling open ICT positions, they often offer higher career flexibility and work-life balance to attract talent, which also constitutes an opportunity for those women (and men) for whom these factors

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<sup>4</sup> Currently active in Bulgaria, France, Germany, Ireland, Spain, the UK and various other countries globally: <https://www.womenwhocode.com/networks>

<sup>5</sup> Currently active in Austria, Belgium, Germany and Switzerland, see <http://www.fintechladies.com/>.

<sup>6</sup> Currently active in various transnational teams, see <https://rladies.org/>.

<sup>7</sup> <http://datapluswomen.com/>

<sup>8</sup> <https://www.wids.ch/>

<sup>9</sup> <https://www.madewithcode.com/>

<sup>10</sup> <https://www.microsoft.com/en-us/diversity/programs/diqgirlz/diqgirlzday.aspx>

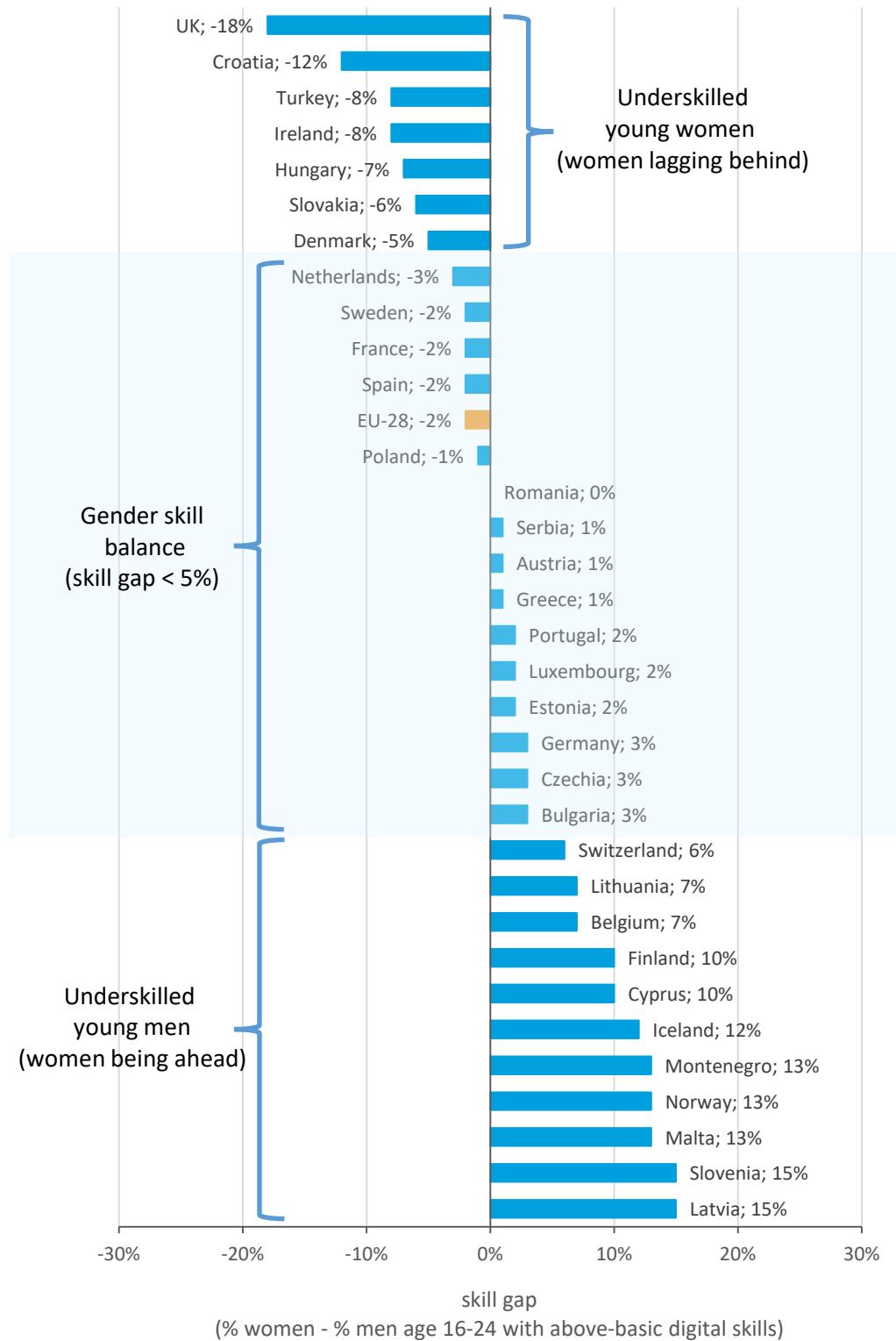
<sup>11</sup> The ECWC Award was only issued in 2016 and is hence not an ongoing initiative. It was a common initiative by the European Commission's DG CONNECT, DG Growth, DG Employment, Social Affairs and Inclusion and the European Centre for Women and Technology (ECWT). For more information see <https://www.genderportal.eu/resources/ecwc-european-celebration-women-computing-award>

<sup>12</sup> <http://adaawards.com/>

<sup>13</sup> For a list of coding bootcamps in Europe, see for example <https://shecancode.io/blog/top-ten-coding-bootcamps-in-europe> (accessed 2019-06-19).

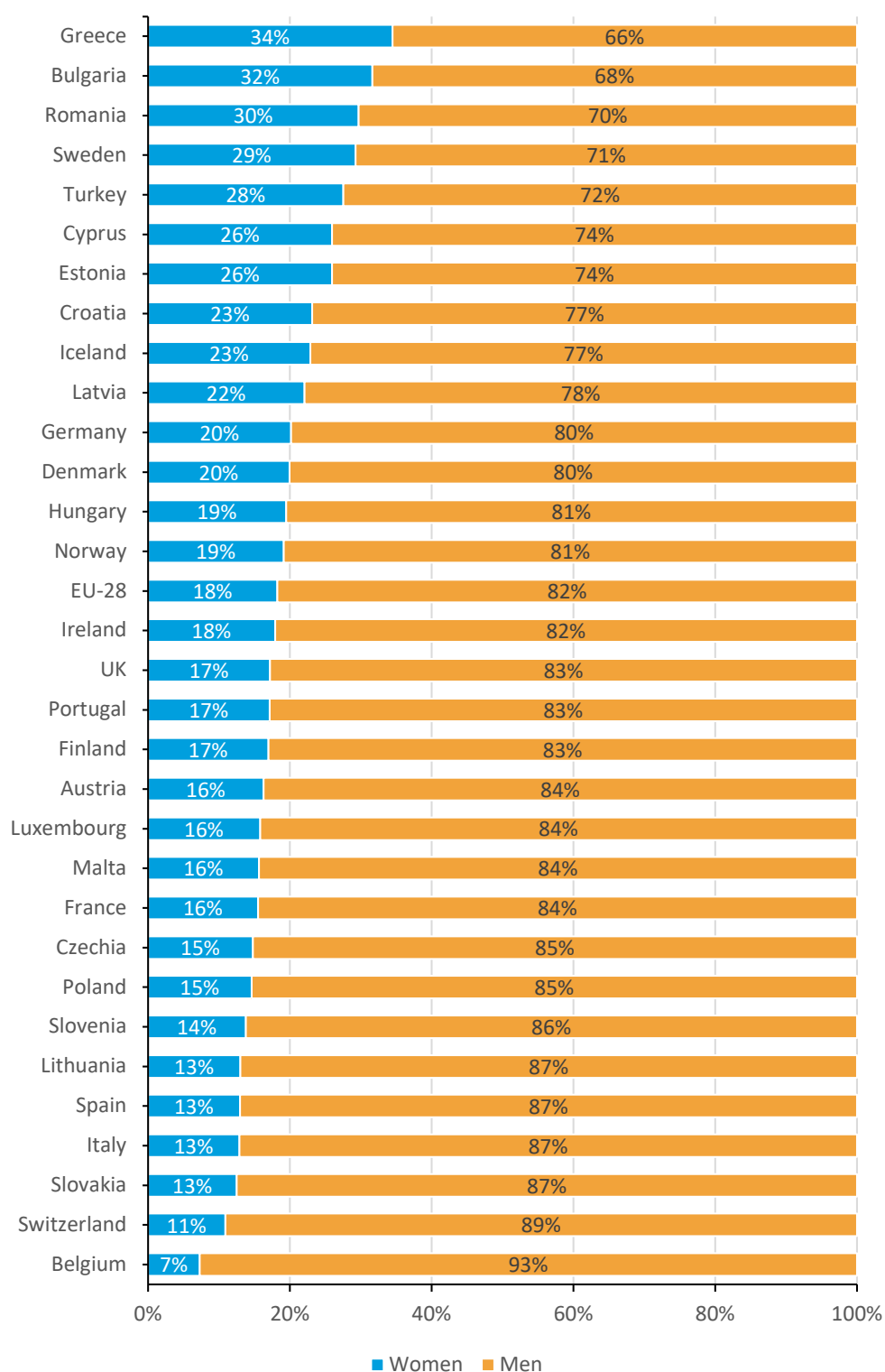
matter. In sum, under the prerequisite of an increasing number of affordable ICT bootcamps, ICT jobs would constitute great opportunities for women, even those with currently non-ICT related backgrounds.

Figure 6 – Skill gap between young women and men across European countries



Source: Eurostat (2019), online code [jsoc\\_sk\\_dskl\\_i](#); own calculations.

Figure 7 – Students enrolled in ICT-subjects by gender, by country



Source: Eurostat (2019), online code [educ\\_uoe\\_enrt03](#); own calculations. ICT-subjects are defined as subjects with ISCED-F 2013 subject code F06 (Information and communication technologies including information and communication technologies not further defined, computer use, database and network design and administration, software and applications development and analysis, information and communication technologies not elsewhere classified as well as inter-disciplinary programmes and qualifications involving information and communication technologies).



### 2.2.3. Refocusing teaching content

#### Setting the scene

Although current teaching theory and practice contain a broad spectrum of innovations (e.g. Vincent-Lancrin et al., 2019), today's teaching content is still mostly based on the transmission of theoretical and factual knowledge. Knowledge and competences taught today are more often subject-related than transversal or applicable to life and professional careers. According to recent research on education, factual knowledge will continue to play an important role as building block to understand larger connections. However, it has been argued that a stronger focus of schools on strategic thinking, decision-making and a sense of agency will help children to become more active and responsible citizens (European Commission, 2018b, p. 75) – aspects we lay out in the following.

#### Anticipating trends and emerging issues

Thinking forward, young students will need more than basic ICT skills and digital competences. Three possible adaptations of what is offered in an educational context are presented in the following: career guidance, computational thinking and entrepreneurship.

#### Career guidance

Digital transformation is associated with increasing specialisation and differentiation of occupations. In the digital sector, new occupations are constantly emerging which, however, often operate in the background and are therefore neither visible nor known to young people. At the same time, some traditional occupations tend to be forgotten and therefore also suffer from a shortage of skilled workers. In consequence, more detailed information about occupations and possible employers could be extremely beneficial and a compelling opportunity both for students<sup>14</sup> and the labour market as a whole – **career guidance could contribute to reducing the skills shortage in the digital age.**

An integral task of school is to prepare the students adequately, to accompany and guide them in their decisions and to show them ways for a successful future (Cedefop, 2018a, p. 14), a task illustrating the close link between career guidance and education in general. The European Lifelong Guidance Policy Network (ELGPN, 2007-2015) defines career guidance as a 'range of activities that enable citizens of any age, and at any point in their lives, to identify their capacities, competences and interests; to make meaningful educational, training and occupational decisions; and to manage their individual life paths in learning, work and other settings in which these capacities and competences are learned and/or used' (ELGPN, 2014).

According to the European Lifelong Guidance Policy Network (ELGPN), '[t]here is increasing international evidence and consensus' that career guidance is 'improving the efficiency and effectiveness of education, training and the labour market through its contribution to reducing drop-out, preventing skills mismatches, increasing job tenure and boosting productivity; and also addressing social equity and social inclusion' (ELGPN, 2014, p. 18; a good overview is provided by Kraatz, 2017, p. 7). Through career guidance, unrealistic expectations of the labour market can be corrected, the student's horizon that is restricted by social and personal characteristics can be broadened (Musset & Kurekova, 2018), and their talents, interests and personalities can be matched with fitting career paths (EPSC, 2017, p. 11). Hence, the greatest **opportunity** of and reason to introduce career guidance is that it brings significant economic and social benefits for the individual as well as for society as a whole.

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<sup>14</sup> In the following, foremost information concerning career guidance for students will be presented. A discussion of lifelong career development can be found in section 2.4.3.

An effective and efficient matching can be accomplished with the help of **labour market information** (short: LMI) that combines various past, present and future indicators, facts and figures, helping forecast future demands for skills, potential bottlenecks and requirements of occupations (Cedefop, 2016b; Fareri et al., 2018, p. 196). Cedefop has developed a LMI toolkit in order to improve the quality of career guidance and support career practitioners with best practices and training (Cedefop, 2018b). Thereby, students can make better informed career choices and ease their transition to the labour market.

Apart from providing information about potential employers, efforts should be made to strengthen **cooperation between employers and students** (Fthenakis & Walbiner, 2018, p.78) and to promote vocational education and training (VET) as a valid option rather than a 'second choice' (European Commission, 2016, p. 6). Through early employer involvement in schools, disadvantaged students without extensive social networks can be supported (Musset & Kurekova, 2018, p. 81).

Since the digital sector continues to grow, but careers in ICT or STEM are not sufficiently taken into consideration, the EC imposes the task on career guidance to increase 'the attractiveness of the ICT sector' and the '[awareness] of the **potential of ICT** for all kinds of professions' (European Commission, 2010, p. 26), also for women. The Grand Coalition for Digital Jobs launched by the European Commission in 2013 and its successor, the Digital Skills and Jobs Coalition (since 2016) are partnerships of stakeholders committed to 'promote the importance of ICT skills, and encourage practical steps to address skills gaps, such as more training opportunities that are aligned to the demands of the workplace' (Vaikutytė-Paškauskė et al., 2018, p. 12). Another practical proposal to increase the tangibility and attractiveness of ICT professions for students is 'an online catalogue for young people with examples and case studies that demonstrate how ICT careers link back to formal curriculum in schools' (Gartland, 2014, p. 11).

Although most EU countries have already introduced some type of career education in schools and/or have declared the launching of new initiatives (EPSC, 2017, p. 11; European Commission, 2018b, p. 16), several indications suggest that there is still **room for improvement**, namely high dropout rates, a perceived poor access to career guidance, challenges in staffing competent advisors and a lack of performance assessment in terms of learning outcomes (European Commission, 2014; Kraatz, 2017, p. 8).

### Computational thinking

In order to enable students to better understand and navigate the digitalised world they live in and will live in, it would prove beneficial if school curricula included computational thinking. In her much discussed and quoted opinion paper from 2006, then vice president of Microsoft Research Jeannette M. Wing defines computational thinking as human thinking which 'involves solving problems, designing systems, and understanding human behaviour, by drawing on the concepts fundamental to computer science' (Wing, 2006). Considering the more recent literature, there is less consensus in terms of a consistent definition of computational thinking. However, according to Bocconi et al., definitions in the current literature agree on the aspects of *abstraction* and *generalisation*, *algorithmic thinking*, as well as *debugging*, *problem decomposition* and *general processes of problem analysis* (Bocconi, Chiocciariello, Dettori, Ferrari, & Engelhardt, 2016, pp. 6–7).

Computer and social scientists have highlighted the importance of implementing computational thinking in school curricula (Allan et al., 2010; Perković et al., 2010; Repenning et al., 2010; Wing, 2007), and this idea is today widely accepted (Bocconi, Chiocciariello, Dettori, Ferrari, Engelhardt et al., 2016). However, the actual **integration of computational thinking in school curricula** varies strongly across EU Member States and can take different forms. Some countries incorporate the skill set into primary education level, others at secondary level (Bocconi, Chiocciariello, Dettori, Ferrari, & Engelhardt, 2016, p. 7). It can also be taught as a subject or multidisciplinary. The impact and

respective effectiveness of different forms of teaching computational thinking have not yet been conclusively assessed (National Research Council, 2011, p. 48).

One example that has been studied particularly often (Tang et al., 2019, p. 8) is the youth programming language Scratch, whose effectiveness on the development of computational thinking has been proven (Marcelino et al., 2018). Using this language, students arrange coloured command blocks to create games, animations, stories and music. It enables them to become familiar with basic concepts of programming in a playful and explorative manner. Similar principles apply to the use of educational robotics (Atmatzidou & Demetriadis, 2016; Bermúdez et al., 2019; Bers et al., 2014; Sullivan & Bers, 2016). Likewise, playing computer games can have positive effects on computational thinking (Ch'ng et al., 2019; Freina et al., 2018; Turchi et al., 2019) and motivate users to start programming (Chiazzese et al., 2018; Garneli & Chorianopoulos, 2018).

A critical challenge for introducing computational thinking into school curricula is to ensure that teachers acquire the appropriate knowledge. There is agreement in the literature that defining aspects of computational thinking should become an integral part of teachers' education and professional development (González Martínez et al., 2018; Yadav, Sands et al., 2017, p. 15; Yadav, Stephenson et al., 2017, p. 62).

Despite the broad agreement among computer and social scientists on its importance, **computational thinking has not yet been implemented in policy frameworks** on education in the digital age. Neither the New Skills Agenda (European Commission, 2016), the Digital Education Action Plan (European Commission, 2018a), nor the Commission's digital competence frameworks DigComp 2.0 (Vuorikari et al., 2016) or 2.1 (Carretero et al., 2017) mention computational thinking explicitly. Most policy documents focus more on digital competence in general (Juškevičienė & Dagiene, 2018). Computational thinking, however, goes beyond the concept of digital competence (Gómez Chova et al., 2016), and therefore should be treated separately. At the same time, there are indications of a growing interest in computational thinking. For example, the Commission's Joint Research Centre (JRC) has recently published on the topic (Bocconi, Chiocciariello, Dettori, Ferrari, & Engelhardt, 2016), and the latest publication of the International Association for the Evaluation of Educational Achievement (IEA) also explicitly addresses students' experiences with computational thinking (Fraillon et al., 2019).

In summary, computational thinking has gained increased attention in recent years. As an addition to 'technical' digital skills, computational thinking represents an ability that will become even more indispensable for future generations, considering the growing role of algorithms and artificial intelligence.

### Entrepreneurship education

Students' motivation and ability to create and innovate is the main component of the concept of entrepreneurship education. Similar to computational thinking, there is no conclusive agreement on its definition. In a narrower sense, entrepreneurship education refers to **building knowledge, skills and abilities necessary for successful business creation and management**, including knowledge about economic processes, resources and finances. A wider definition includes several transversal skills such as creativity, critical and strategic thinking, problem solving, collaboration, negotiation, courage and perseverance (Council of the European Union, 2018). These skills become increasingly important in the digital age and can help to successfully master both academic and professional careers in a digitalised society.

A key reason for entrepreneurship to be a desired competence is the premise that a basic understanding and interest in it **promotes the establishment of start-ups** (European Commission, 2013a). As 'in the digital economy tech startups are at the forefront of (...) growth [and of job creation]' (Gartland, 2014, p. 14), the willingness to start businesses should be encouraged. Similarly, the strategic framework for European cooperation in education and training (ET 2020) defines that

'[c]reativity and innovation are crucial to enterprise development and to Europe's ability to compete internationally' (Council of the European Union, 2009, p. 4).

Unfortunately, less than half of EU citizens have stated that their school education fostered their understanding of the 'role of entrepreneurs in society (47 %) or gave them the skills and know-how to enable them to run a business (41 %) [or] made them interested in becoming an entrepreneur (28 %)' (Cedefop, 2014). Consequently, policy should focus on increasing both the quantity and the quality of entrepreneurship education in schools, whether this be achieved interdisciplinary, as an independent subject or at least in mandatory projects. **Additionally, schools should allow for a practical perspective and place more emphasis on practical experience.**

Entrepreneurship education forms already part of the EU key competences for lifelong learning. In the corresponding communication, the Council asks its Member States for action in 'nurturing entrepreneurship competence, creativity and the sense of initiative especially among young people, for example by promoting opportunities for young learners to undertake at least one practical entrepreneurial experience during their school education' (Council of the European Union, 2018). These efforts should, according to the European Commission's Entrepreneurship 2020 Action Plan, also initiate cultural change and possibly create better framework conditions for entrepreneurial endeavours (European Commission, 2013a).

On a more practical level, the EC and the OECD have initiated the joint initiative Entrepreneurship360 to examine entrepreneurial learning in the education systems of its Member States. As a result, a website was created where a comprehensive list of initiatives and best practice examples can be accessed filtered by country and criteria (OECD, 2019b). The accompanying background paper summarises the **difficulties that arise when implementing entrepreneurship into education**: 'Lack of time and resources, teachers' fear of commercialism, impeding educational structures, assessment difficulties and lack of definitional clarity are some of the challenges practitioners have encountered when trying to infuse entrepreneurship into education' (Lackéus, 2015).

In order to 'develop a common conceptual approach' (Bacigalupo et al., 2016) and to define educational goals, the European Commission has created an Entrepreneurship Competence Framework (EntreComp) encompassing 15 competences and a list of 442 learning outcomes and strives to bridge 'the worlds of education and work' (Bacigalupo et al., 2016). It is designed to be used as a reference for education and training authorities and practitioners in formal and non-formal learning contexts.

### 2.3. Educators and trainers in a changing education system

Educators and trainers play a crucial role in implementing digital technologies into school life (e.g. Pastor and Quirós, 2015). They are regarded as central drivers of a successful digital transformation in the classroom (OECD, 2015b, p. 191), a role that requires strong digital competences (Pastor and Quirós, 2015, pp. 46–47). As pointed out by the OECD, the mere accessibility of devices, services and networks will not in itself make education meet the necessities of the digital age (OECD, 2015, p. 190). Teachers need training that empowers them to identify and choose the most suitable applications from a broad range of different options available for teaching and learning, and apply them in meaningful contexts in class. In the following, we discuss two closely related aspects considering educators and trainers: new technologies in support of teaching and the promotion of teachers' digital confidence and competence through professional development.

### 2.3.1. New technologies in support of teaching

#### Setting the scene

The current range of educational innovations like learning platforms, learning management systems and online collaboration is large and constitutes a constantly growing market. However, these technologies will only enter the classroom if teachers know and introduce them into teaching practice.

#### Teachers' current experience and involvement with ICT

Although a majority of the interviewed teachers in the last International Computer and Information Literacy Study (ICILS) reported having five or more years of experience with using ICT during lessons (65 %) and for preparing lessons (72 %), **only about half of all teachers actually utilise ICT every day at school when teaching** (Fraillon et al., 2019, p. 179). A detailed look also reveals that **teachers tend to use general utility ICT tools for predominantly simple tasks rather than specialised learning and teaching applications**. Again, there are significant differences between countries. While Denmark's overall results are above average and stand out especially in the last category, in other European countries only about one third of teachers use ICT every day (Fraillon et al., 2019, p. 179).

A possible reason for the infrequent use of specialised learning and teaching applications could be a both quantitatively and qualitatively inadequate provision of teacher training (also see section 2.3.2). While about a third of surveyed teachers in the 2<sup>nd</sup> Survey of Schools had taken introductory ICT related courses across all ISCED-levels, only between 14 % and 25 % completed advanced courses on internet use or applications (Deloitte & Ipsos, 2019a, p. 83).

Teachers' outlook on digital technologies in schools does not seem to be the issue, because the last International Computer and Information Literacy Study (ICILS) 2018 indicates a **widespread recognition among teachers of positive benefits from using ICT in teaching**. A vast majority of teachers (above 85 %) agrees that ICT 'helps students develop greater interest in learning', 'enables students to access better sources of information' and 'helps students to work at a level appropriate to their learning needs' (Fraillon et al., 2019, p. 183). Negative outcomes were assessed ambivalently by the teachers. Only the concern that students might copy material from internet sources was expressed frequently.

The challenge lies in introducing and familiarising teachers with digital learning opportunities. Therefore, one already popular approach and four technologies with potential for the future are presented in the following.

#### Bring Your Own Device (BYOD)

*Bring Your Own Device* (BYOD) refers to students bringing their own laptops, tablets, smartphones, or other mobile devices to class and using them for educational purposes (Johnson et al., 2015). Currently a European average of 30 % of ISCED-2 and 53 % of ISCED-3 students use their own smartphones during lessons at least once a week for learning purposes (Deloitte & Ipsos, 2019a, p. 42). However, the figures vary considerably across European countries.

BYOD approaches have both proponents and critics.<sup>15</sup> On the one side, its proponents consider it to be a cost-efficient substitute for schools to compensate for deficiencies in their digital infrastructure (e.g. Conrads et al., 2017). Furthermore, **by bringing their own devices students may feel more motivated to use smartphones as learning platforms**. BYOD may help students bridge the gap between spare time and school time, and thus generate positive outcomes to teaching and learning.

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<sup>15</sup> For an overview of the most salient arguments, see Renard (2016).

Finally, BYOD could help students learn how to use their own devices in 'socially and pedagogically acceptable ways' (IPOL, 2015, p. 11).

On the other hand, opponents of BYOD argue that **having one's own device turned on at school may increase distraction and lead to unintended uses of devices** (e.g. parallel chat messages between students not related to educational content (cf. Cho & Steiner, 2015; Renard, 2016; Selwyn et al., 2017). It has also been argued that BYOD approaches may increase the prevalence of cyberbullying (e.g. Kumar, 2015). Moreover, not all students may have devices, or students may have different devices, making it more difficult to run certain applications and thereby making it more tedious for teachers to help with technical issues (Renard, 2016).

In sum, the discussion around BYOD underlines the importance of teachers' pedagogical work, such as setting and enforcing rules around the use of digital devices. This implies that teachers should be enabled and empowered to use technology in pedagogically meaningful ways, a topic discussed in more detail in section 2.3.2 below. Furthermore, scientific evidence on the effects of BYOD-based teaching is sparse and contradictory. Further research would be necessary to establish in which contexts and under which circumstances BYOD-based teaching results in better outcomes than other teaching methods.

### Anticipating trends and emerging issues

In the following, four technologies and teaching concepts are presented that are expected to gain importance in tomorrow's education.

#### Artificial intelligence

Artificial intelligence (AI) in general refers to 'computer systems able to perform tasks normally requiring human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages' (Oxford Dictionaries, 2019a). A closely related concept is that of self-learning algorithms, that is, computer programs that learn and adapt with each new input they receive. An increasing number of publications discuss applications of artificial intelligence and self-learning algorithms in education (e.g. Baker et al., 2019; Goksel & Bozkurt, 2019; Karsenti, 2019; Tuomi, 2018).

Three interrelated applications of artificial intelligence and self-learning algorithms appear of specific relevance for education:

- learning analytics,
- the personalisation of learning content, and
- the monitoring and control of learners' behaviour.

**Learning analytics** involve the 'measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning' (Ferguson et al., 2016, p. 8). Learning analytics not only evaluates how well students are doing at the moment, but promises to assess how well they will do in the future.<sup>16</sup> On the one hand, learning analytics offer options for monitoring and governance to answer questions related to student performance across grades, schools, and regions (cf. Williamson, 2016). On the other hand, learning analytics enable the personalisation of learning content (cf. Maselena et al., 2018).

The **personalisation of learning content** refers to applications where students receive tasks based on their personal level of performance and their individual learning behaviour – so-called 'adaptive learning environments' or 'smart learning' (e.g. Peng et al., 2019; Spector, 2014; Kinshuk et al., 2016).

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<sup>16</sup> Such predictions of future performance are part of so-called predictive analytics (cf. Williamson, 2016).

It is argued that the personalisation of learning content improves the engagement and motivation of learners, and accelerates learning (e.g. Peng et al., 2019). However, empirical research testing this assumption is still relatively sparse.

Finally, artificial intelligence allows the **monitoring of learners' behaviour** going far beyond performance tracking in learning apps. An often-cited example is facial recognition technology to monitor students' attention as it is currently applied in China (e.g. Connor, 2018). Such developments raise questions about data protection, ethics and the role of policy and politics (Tuomi, 2018, p. 4).

#### Augmented and virtual reality

Augmented reality (AR) and virtual reality (VR) can facilitate innovative ways of teaching and learning (for an overview, see Akçayır & Akçayır, 2017). Fthenakis and Walbiner predict that AR and VR will dramatically change current learning settings (2018, pp. 117–118). Due to their interactive formats in realistic settings, these applications can increase learners' motivation and the retention of learning content (Ascione, 2018; Hwang et al., 2016; Stargame, 2018). Currently AR and VR applications are **mostly used for vocational training**, e.g. in machine and heavy equipment simulators. A central requirement for such applications, according to the EU Commission, will be high-speed internet connectivity (Deloitte & Ipsos, 2019a, p. 22; European Commission, 2018a).

#### Blockchain

Blockchain is basically a decentralised database for transactions between parties that transparently records every change and is accessible from everywhere (Stanley, 2018). A recent study addresses the opportunities of blockchain in education and concludes that blockchain applications in educational contexts are 'still in their infancy', but nonetheless 'quickly picking up steam' (Grech & Camilleri, 2017, p. 8). Among others, the following application areas are identified as particularly promising: **certification, issuance and recognition of degrees, tracking of academic content and work, and management of payments and cash flows such as tuition fees** (Camilleri et al., 2019). By allowing easy access from anywhere, information like certificates can be retrieved immediately and be further processed by requesting institutions having the permission to read the data. Based on this data, so-called 'smart-contracts' could be created, which could greatly speed up processes such as requesting government financial aid (Grech & Camilleri, 2017). In general, blockchain offers various opportunities to simplify and accelerate processes in higher education, also in cross-national procedures across the European Union.

#### Highly equipped and connected classrooms

Highly equipped and connected classrooms (HECC) are future scenarios suggested by a recent study commissioned by the European Commission (Deloitte & Ipsos, 2019b). Three possible levels of HECC are identified, based on different variations of the following dimensions: digital equipment, network requirements, professional teacher development and access to digital content. The most advanced scenario, called 'cutting-edge level scenario', draws a picture of schools equipped with laptops, e-books, VR-headsets, voice assistants, wearable wristbands, as well as audio and video editing software. 'Cutting-edge level scenarios' also include ultra-fast broadband networks and constant professional development and leadership training for teachers.

The presented technologies – artificial intelligence, virtual reality, blockchain and highly equipped classrooms – illustrate the great potential, but also challenges lying ahead for ICT-enabled teaching and learning. Implementation of these technologies to the classroom are still in their early stages. More research will be necessary to assess advantages and disadvantages, criteria for their successful application, and to create a wider public acceptance. A general scientific ethics council would prove useful in this case. Agreement must also be reached on the use of certain instruments, so that teachers can be trained on the specific application.

## 2.3.2. Building teachers' digital confidence and competence through professional development

### Setting the scene

A lack of self-confidence among teachers is commonly seen as a central barrier to the successful use of digital technologies in education (Baker et al., 2019; OECD, 2018, p. 8; Vaikutytė-Paškauskė et al., 2018, p. 24). In the following, confidence in the handling of digital technology will be referred to as 'digital confidence', a concept closely connected to that of digital competence.

**In the process of integrating digital technology into education, critical aspects in its success are teachers' digital competences, digital confidence and their mindset towards new technologies** (European Schoolnet, 2013). Along the same line, there is evidence that teachers' confidence in technology use positively affects the frequency with which students use ICT for learning (European Schoolnet, 2013). However, **the majority of today's teachers only feel sufficiently confident in administrative and basic digital tasks** (e.g. producing text documents and sending emails), but far less confident with regard to more complex digital tasks such as programming or creating databases (Deloitte & Ipsos, 2019a, p. 52). In short, European students are still taught by teachers who are neither sufficiently digitally confident nor sufficiently supportive (Conrads et al., 2017, p. 6).

This raises the central question of how digital confidence of teachers can be improved across the board. Several authors were able to demonstrate that **professional development activities, and the digital skills developed through it are closely related to teachers' digital confidence** (Deloitte & Ipsos, 2019a; OECD, 2018, p. 8; Sugar, 2005). As a result, the scientific debate on the subject of teachers' digital competences is unanimous in the importance of professional development (European Schoolnet, 2013; Łybacka & Kozłowska-Rajewicz, 2018; Nogueira & Prutsch, 2015, p. 11), especially for the integration of new technologies (Bocconi, Chiocciariello, Dettori, Ferrari, & Engelhardt, 2016, p. 7; OECD, 2016a, p. 8). In its communication on school development and excellent teaching to the European Parliament, the European Commission supports professional development of teachers by strengthening peer learning, facilitating access to Erasmus+ exchange programmes and developing specialised online communities for further education (European Commission, 2017, p. 7). However, it should be mentioned that professional development is difficult or even impossible to standardise due to the different school systems in Europe. Although framework conditions can be set, no obligation can be obtained from the respective countries. Each country has its own regulations in the area of teacher training, advanced training or other similar areas. The German federal states, for example, have independent school systems with distinct specifications for professional development in teachers' training. This is particularly evident in the differences in compulsory ICT training across Member states which ranges from less than 10 % to about 75 % teacher participation (Deloitte & Ipsos, 2019a, p. 80). Many teachers (60 % in all ISCED levels) rely on learning how to use new technologies in their free time (Deloitte & Ipsos, 2019a, p. 78).

In the following paragraphs, the scientific debate on professional development of teachers' digital competences will be discussed in more detail.



## Measuring teachers' digital competence

An institutionalised and scientifically grounded approach to measure teachers' digital competence is the **'European Framework for the Digital Competence of Educators (DigCompEdu)'**, a self-assessment tool provided by the European Commission. DigCompEdu divides digital competence into two aspects: **'Educators' Professional Competences'** and **'Educators' Pedagogic Competences'** (Redecker and Punie, 2017, p. 16).

'Educators' Professional Competences' refers to digital competences in communication and basic administrative tasks, but also competences in professional teacher collaboration. 'Educators' Pedagogic Competences' constitutes the competence of pedagogical handling of digital teaching topics such as 'Digital Resources', 'Teaching and Learning', 'Assessment' and 'Empowering Learners' (Redecker and Punie, 2017).

DigCompEdu is a practical approach helping 'educators understand their personal strengths and weaknesses' (Redecker and Punie, 2017, p. 29). The framework serves as self-assessment and as critical self-evaluation for interested teachers.

More information can be obtained at <https://ec.europa.eu/jrc/en/digcompedu>.

## Current state of teachers' participation in the professional development of digital competences

The following gives a rough overview of the current state of teachers' participation in professional development activities<sup>17</sup> as resulting from the '2<sup>nd</sup> Survey of Schools' commissioned by the European Commission (Deloitte & Ipsos, 2019a, p. 83):

- 43 % (ISCED-level 1) to 50 % (ISCED-level 3) of European students are taught by teachers who took pedagogical courses on the use of ICT in the past two years. The distribution for 2011-2012 is similar.
- In contrast to the preceding survey from 2011-2012, the number of students taught by teachers who have received subject-related training on learning applications increased from 21 % to 44 % at ISCED-level 1 and from 33 % to 49 % at ISCED-level 2.
- The number of students who are taught by teachers who undertook equipment-specific training decreased from 54 % to 46 % at ISCED-level 1 and from 64 % to 45 % at ISCED-level 2.

In regard to digital competences in education, the **pedagogical usage of ICT** and **subject-related ICT training** seem to be especially important topics. The results of the '2<sup>nd</sup> Survey of Schools' show that an increasing value is placed on subject-related training. Participation in pedagogical courses on ICT has remained at similar levels as in 2011-2012. Only the proportion of teachers participating in equipment-specific training has declined in recent years. This may be due to the increased user-friendliness of teaching technology and to an increasing number of digital native and/or digitally skilled teachers, lowering the need among teachers for further equipment-specific training.

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<sup>17</sup> Topics that fall into professional development, but not into digital competencies (e.g. pedagogic competences not related to technology) are excluded. For a brief overview of current professional development for teachers in OECD countries, including non-digital content, we refer to the OECD report on 'Measuring Innovation in Education 2019' (Vincent-Lancrin et al., 2019, pp. 117–211).

One other significant point is **unequal access to and unequal participation in professional development across European countries**, as indicated by results from the '2nd Survey of Schools' (Deloitte & Ipsos, 2019b) and a study issued by the OECD economy (OECD, 2017b). According to the OECD, access to professional development depends both on teachers' gender and their country's economy (2017b), an issue that should be of relevance for Europe's cohesion policy.

### Anticipating trends and emerging issues

Concerning the future of teachers' professional development, Vuorikari (2019) identifies the following innovative approaches and emerging trends:

1. Professional development is increasingly taking place at schools or in its vicinity. Training occurs increasingly in a **job-embedded context** when teachers work together collaboratively. This stands in strong contrast to attending training facilities and undertaking top-down lecturing.
2. Professional development **is increasingly taking place online**. Through innovations in the field of e-learning and the low threshold access of online provision, teachers are increasingly able to pursue their training at any time and from any place, fitting professional training more flexibly into their schedule. For providers of online training, scalability effects make them economically attractive.
3. **Blended learning**, i.e. the combination of online teaching and traditional classroom methods, is currently being re-invented. In addition to classic blended learning methods, practical hands-on experience where teachers experiment with new teaching methods are increasingly offered.

Good examples in which the above trends are being expressed are new forms of network-based teacher cooperation. Teacher cooperation is an integral part of European education policy (e.g. Pateraki, 2018). In fact, the EU-wide programme Erasmus+ offers a set of tools for exchanging best practices, peer learning and professional development of teachers. One of these tools is the **eTwinning – The community for schools in Europe** – programme where teachers exchange professional experiences (Pateraki, 2018). Registered users, mostly teachers, have the opportunity to participate in professional development activities such as online courses, learning events, online seminars and mutual exchange and collaboration. Networks offer teachers collaboration, exchange and the chance to spread innovations into other schools. In a community of like-minded people, teachers may feel more motivated and committed to improving their digital competences. There is evidence that participating in the eTwinning programme has a positive impact on digital competences (Pateraki, 2018, p. 25).

At the same time, **the question persists whether more motivated teachers self-select into teachers training and how less proactive teachers could be reached**. It is very possible that more engaged teachers are more likely to actively participate in training programmes. Furthermore, a central barrier to teachers' participation in professional development are conflicts with their working schedule (Vuorikari, 2019, p. 5). If courses do not allow teachers to participate independently in relation to time and location, large-scale roll-outs of teachers training will prove to be difficult.

Finally, the acquisition of certificates for professional development constitutes an issue. Especially in network-based collaboration such as e-Twinning, **instruments to build digital competence that have proven to be effective are often not standardised and informal in character**, entailing problems with obtaining certificates or other career-promoting proofs of the acquired competences (Vuorikari, 2019). This could constitute a discouragement for teachers to take part in such professional development activities.

## 2.4. Employers and employees in a changing labour market

The success of businesses and employers depends on the educational system in the sense that schools, vocational training or university produce a skilled and competent labour force indispensable for a prospering economy. This section shows how the labour market will be transformed by digital technologies and which consequences this entails for education in the digital age.

### 2.4.1. The changing nature of work in the digital age

#### Setting the scene

The digital transformation is re-shaping the professional world in a number of ways. Communication and collaboration has become faster, easier and globally available, the expansion of the online world has paved the way for new business models and professions, and physical labour and routine tasks are being increasingly taken over by robots and automation. These changes are affecting characteristics of the future job market such as work organisation, employer–employee relations and skill requirements, and thereby also influence what today's education has to achieve.

#### Work-life-balance as a benefit of digital technologies

ICT and digital technologies are part of everyday working life for the majority of today's employees. The European Digital Skills Survey gathered data from 7800 workplaces, over 90% of which use desktop computers with broadband connection to the internet (Curtarelli et al., 2017). Portable computers (75%) and other portable devices (63%) are also widely spread, which allows employees to organise their work more flexibly in terms of time and location. Corresponding agreements between employers and employees can **benefit the work-life-balance** and the feeling of autonomy and independence. Owing to technology, employees can more easily arrange their working hours according to family and social commitments, which is supported by the European Institute for Gender Equality as establishing favourable working conditions for women (EIGE, 2018a, p. 2). At the same time, the European Commission warns that working remotely from home and the obligation to be constantly available through email and phone can dissolve the dividing line between work and leisure and cause increased stress and burn-out (Curtarelli et al., 2017; European Commission, 2016). Hence, today's education should include lessons on self-management and resilience and foster the future generation's ability to take part proactively in shaping the environment they will work in.

#### Anticipating trends and emerging issues

New forms of employment, as compiled in a study by Eurofond (2015, pp. 1–2), commonly feature a high level of flexibility for employers and employees.

#### Progressively more mobile and dynamic work biographies

Especially the young generation of workers seek independence, tend to switch between jobs more frequently, and prefer flat hierarchies and 'a culture of cooperation and self-organised collaboration in increasingly virtual teams' (Bughin et al., 2018, p. 40; Daheim & Wintermann, 2016, p. 15). These preferences are indicators of emerging trends and supplement the developments in the labour market as supported by data from the 'Future of Jobs Survey' of the World Economic Forum. It reveals that **44% of the interviewed employees rate the category 'changing nature of work, flexible work' as a top trend** (World Economic Forum, 2016, p. 8).

The new flexibility also enriches the possibilities for employers to organise and structure the work environment which includes sharing jobs or employees, hiring for specific projects, and utilising collaborative and crowd employment. There is also the trend of offering individual tasks and services over online platforms (Dachs, 2018, p. 21), which makes fixed office spaces obsolete and

boosts business models such as mobile offices and coworking spaces (Zenhäusern & Vaterlaus, 2017, p. 37). **As a result, traditional career models and fixed contract employment may be increasingly replaced by more fluid and less linear career paths and an increasing number of freelancing and self-employment** (Daheim & Wintermann, 2016, p. 15; Gartland, 2014, p. 34).

In order to prepare students for agile working methods, teamwork and project management should be encouraged more strongly in schools, for example by utilising more interdisciplinary project work. Less long-term employment contracts entail that students must learn to proactively manage their careers and to be resilient to uncertainty.

New forms of employment call for structural changes

The new forms of employment carry a risk of uncertainty and presumably more gaps in one's professional life. A study for the European Parliament on 'The impact on new technologies on the labour market and the social economy' suggests that certain new types of employment should be reviewed regarding their specifications and requirements, for example for social security (Dachs, 2018, p. 6). Likewise, the European Foundation for the Improvement of Living and Working Conditions (Eurofound) mentions that policy-makers will need to implement **new employment regulations** and adapt their social systems in order to find a balance 'between the protection of workers and the need to make these new forms easy for employers to use' (2015, pp. 2–3). Additionally, the system of higher education and vocational training might have to adapt in the future by better integrating the concept of lifelong learning (see section 2.4.4) into existing institutional and political structures. The options of studying or gaining further vocational qualifications at various points in life should be **made more accessible**.

## 2.4.2. Automation challenges current occupational composition

Setting the scene

Besides a more flexible and project-oriented organisation of work and diverse forms of employment contracts, digitalisation is disrupting the labour market in form of automation and the use of artificial intelligence.

In the last 20 years, the share of high-skilled jobs in total employment has risen by 7.6%, whereas jobs for employees with middle qualifications have declined by almost 10% (Zenhäusern & Vaterlaus, 2017, p. 6). Low-skilled occupations are less affected by automation and relocation, because they involve tasks that require interaction and physical contact (e.g. manual activities such as janitorial work, security personnel). Conversely, work in production and basic cognitive tasks like data input are replaceable by machines and algorithms. This trend has been coined '**job polarisation**' (Dachs, 2018, p. 18; Fareri et al., 2018, p. 18).

Economic experts from the World Bank and researchers from the International Federation of Robotics expect that the implementation of digital technologies may contribute to productivity increases by taking over repetitive tasks and hard labour (IFR, 2017; World Bank, 2019, vii). However, this development causes displeasure among parts of the population, which fear a destruction of jobs. Especially workers with poor or middle education and training and few digital skills **fear being replaced by technology**.

The apprehension of change or unemployment might affect people's behaviour and the population's disposition. The European skills and jobs survey (ESJS) examined the sentiment of the European population and found that almost half of the adult employees in the EU labour market think that it is moderately likely or very likely that several of their skills will become outdated in the next five years (Cedefop, 2018a, p. 25). This finding indicates that it is important to provide the concerned population with a perspective by preparing them for the coming changes and facilitating their personal development in the form of lifelong learning.

## Anticipating trends and emerging issues

The extent to which substitutions of skills and jobs might happen is under discussion and seems to depend heavily on the definition and interpretation of data. Some studies predict that '65 % of all activities that are currently performed by humans will be automatable' within the coming 10 to 20 years (Hoell et al., 2018, p. 6) and over 50 % of jobs will be made obsolete within this time frame (Frey & Osborne, 2013). In contrast, recent OECD Employment Outlook (2019a) data shows that only about 14 % of jobs in OECD countries have the potential to be fully substituted by technology, but another 32 % will be radically transformed.

Even though the digital transformation will also create new jobs and occupations, the employees at risk will not be suited to perform these tasks, because the **new tasks demand high and specialist qualifications**. A study for the European Parliament's Committee on Employment and Social Affairs on the Digital Single Market Strategy indicates that 'most new jobs [...] will be in knowledge- and skill-intensive occupations, such as high level managerial and technical jobs' (Valsamis et al., 2015).

In summary, it has become clear that the characteristics of the job market will change substantially. As new forms of work emerge and the tech industry steadily grows, the demand for manual skills and middle qualifications decreases. Even though job destruction by automation will only occur for a small portion of occupations a larger share of employees will have to face significant changes in their day-to-day work. Since various industries and occupations are being digitalised, they now require digital competences and higher education (Colebrook et al., 2015, p. 26). Unfortunately, the rapid technological changes face a slower adaptation process in the workforce and the education system, which causes skill and qualification mismatches.

### 2.4.3. Challenges to match available skills with job market requirements

#### Setting the scene

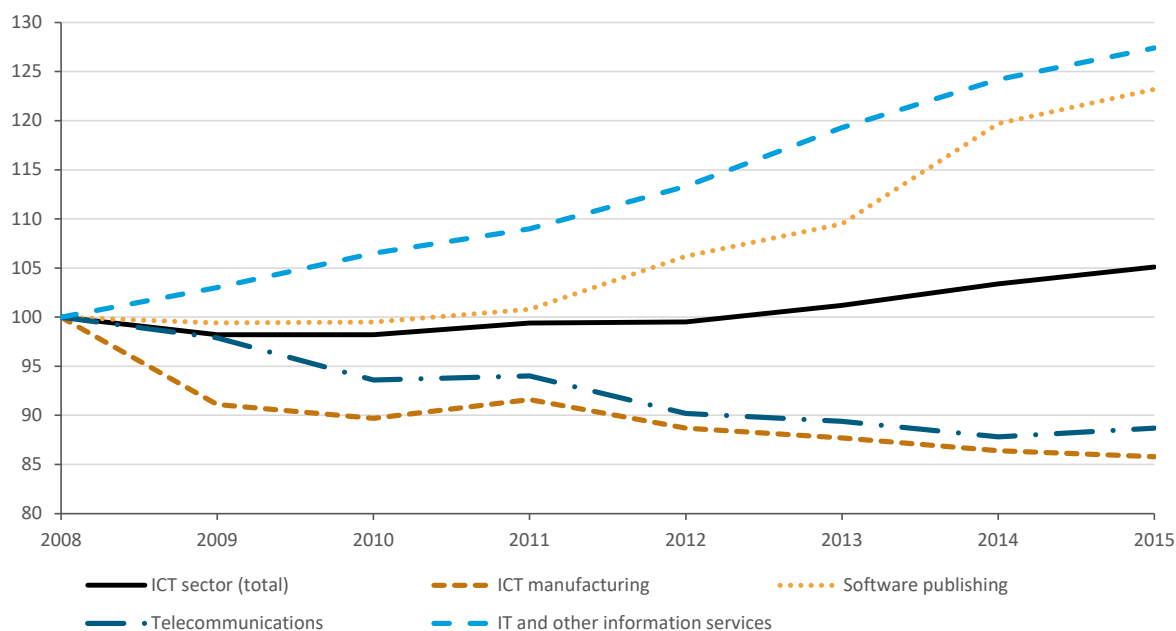
At first glance, the shift in skill requirements towards higher competences does not seem to be a problem, because **the overall qualification level of the European workforce is constantly rising**. Data from the European Statistical Office (Eurostat) shows that in a period of 12 years, the share of workers with only lower-level education decreased from 28 to 18 %, while the proportion with a tertiary education increased from 23 to 33 %.

#### Qualification and skill mismatches

Most of the effect can be attributed to the upcoming generations that seek higher education, because it used to be a guarantee for a job (EPSC, 2017, p. 11). Even though this fact is still partly true and the chance of finding a job is highest for well-educated individuals (only 4.2 % were unemployed in 2017 in contrast to almost 14 % of low-qualified adults of working age) (Cedefop, 2019b), Europe faces persistently high levels of youth unemployment. This leads to young graduates struggling to find adequate employment despite their degrees. **As a result, new entrants accept jobs that do not match their qualification**. Eurostat data estimates an average over-qualification rate of tertiary graduates of 26 % (Cedefop, 2019a). Regarding the overall workforce, the OECD's Survey of Adult Skills (PIAAC) reveals that about 22 % report to be overqualified and about 13 % to be underqualified for their recent jobs (OECD, 2016c). A study with data from Cedefop's European skills and jobs survey (ESJS) clarifies that workers who are underqualified can benefit from the mismatch, because they have the opportunity to accomplish the more demanding tasks and learn on the job (Cedefop, 2015; van der Velden & Verhaest, 2017). Employees with a qualification surplus on the other hand experience mostly negative effects, such as lower wages, decreased work performance because of dissatisfaction, and limitations to their potential career progress in so called 'dead-end jobs' (Cedefop, 2015). At a company level, qualification mismatches interfere with productivity, because the employees' potential is not fully utilised as they could be accomplishing more complex tasks (Kiss, 2016).

In addition to the qualification mismatch, employers are being confronted with the challenge of a **skill mismatch**. This means that the need for certain degrees and types of skills is higher than their supply, whereas there is a surplus of graduates in other fields of study. Particular bottlenecks, also called shortages or skill gaps<sup>18</sup>, arise in the area of ICT.

Figure 8 – Growth of employment in the ICT sector and its sub-sectors in the OECD area



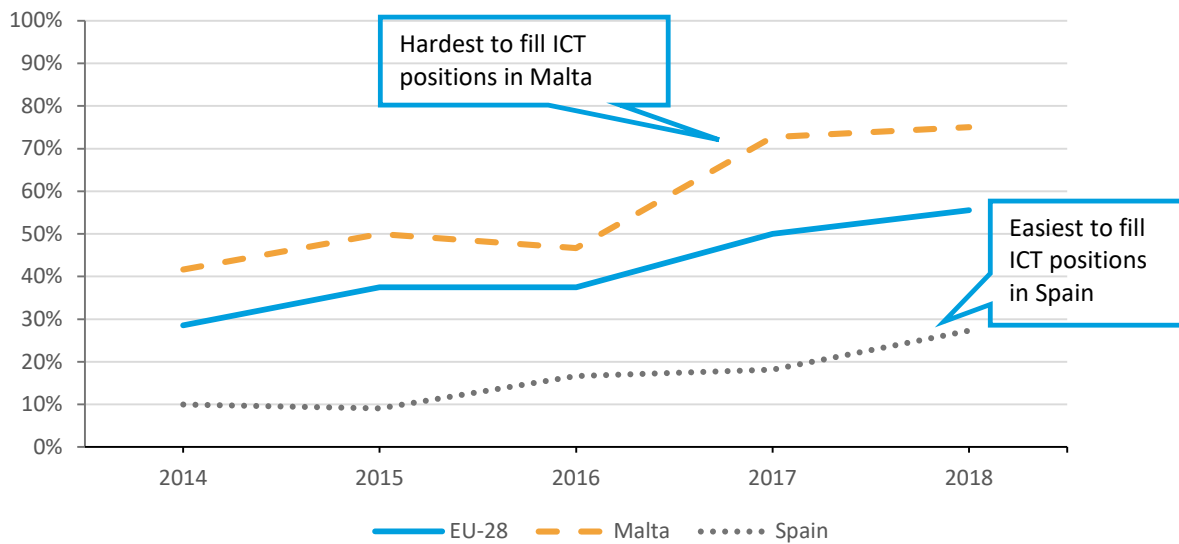
Number of persons employed (2008 = 100). Source: OECD (2017a).

Since 2008, employment in the ICT sector has risen considerably in OECD states, especially in industries with higher skill requirements. Meanwhile, affirming the statements about middle qualifications made in the previous paragraphs, ICT manufacturing is on decline. The logical conclusion that can be drawn from the graph in figure 8 is **that employees with IT and software knowledge are increasingly in demand** (Kiss, 2016; see also OECD, 2016b, pp. 6–12). This can also be seen in the share of open vacancies in ICT that are filled only after a long time or not at all. As shown in figure 9, recruitment difficulties for ICT positions have been increasing since 2014 from an EU average of almost 30 % to about 55 % in 2018. The striking differences between European countries, with Malta being the country where it is hardest to fill open vacancies and Spain being the country where it is easiest, depends heavily on factors like the economic situation and industry composition in these countries.

Similar to the qualifications mismatch, the skill mismatch has a negative impact on the efficiency and operating range of the companies concerned. Not only is the daily work affected by the lack of trained ICT experts, but also the possibility of companies to introduce innovations and improvements, which also hinders future productivity.

<sup>18</sup> Only 'genuine skill shortages' (Cedefop 2018a, p. 41) are considered here, which means all other criteria, such as a competitive salary and good employment conditions, are met.

Figure 9 – Percentage of ICT positions that were hard to fill (2014-2018)



Source: Eurostat (2019), online code [isoc\\_ci\\_eu\\_en2](#); own calculations. Malta is the country in which it was the most difficult to fill ICT positions, Spain is the country in which it was easiest. The percentage refers to the number of enterprises having hard-to-fill vacancies for jobs requiring ICT specialist skills in relation to the number of enterprises recruiting or trying to recruit personnel for jobs requiring ICT specialist skills.

### Approaching skill mismatches

**Identification of supply and demand for skills** is a first step towards solving the mismatch. The EU is already investing in addressing this issue through several measures, namely Cedefop's European skills forecast, the European skills index, the European skills and jobs survey, and the Skills Online Vacancy Analysis Tool for Europe (Skills OVATE). Additionally, the OECD provides the database 'Skills for jobs' with information for 40 countries (OECD, 2019c). These tools provide up-to-date insights on current and emerging skill needs, which can 'support citizens in making better career and training choices' (Cedefop, 2019c).

To further counteract a persistent mismatch, the information obtained must be made available to students, for example through a better link to training and career guidance (see section 2.2.3). In this way, a deeper insight into the requirements of the working world can be provided at an early stage in school and possible adjustments and career plans can be made.

### Complementary skill sets

Besides the increase in IT/ICT specialist positions and their corresponding skills, the **demand for digital competences is rising in almost all industries and occupations** (European Commission, 2016, pp. 7–8). Fortunately, fundamental knowledge can easily be obtained by upskilling or reskilling of the current workforce as short-term measures (Hoell et al., 2018, p. 8) and maintained in a process of lifelong learning. Even though in ESJS 2014, the majority of employees (between 60 % and 80 %) reported only needing a basic or moderate level of ICT skills for their job (Cedefop, 2018a, p. 53), one strong indicator for the digital transformation of the professional world is the fact that about 70 % of newly emerged job titles are directly related to digital technologies (Zenhäusern & Vaterlaus, 2017, p. 33).

In addition to a stronger focus on digital competences, more attention needs to be paid to transversal skills. **The urgent necessity to foster these skills in today's students** is depicted in the PISA assessment of collaborative problem-solving skills. 'On average across OECD countries, fewer

than one in ten 15-year-old students could complete problem-solving tasks that required them to maintain awareness of group dynamics, take actions to overcome obstacles and resolve disagreements with others, even when the content of these tasks was relatively simple' (Schleicher, 2018, p. 32). Similar results were found in the International Computer and Information Literacy Study (ICILS) 2013 which assesses the digital competences of students worldwide: 'only a small 2 % achieved [the highest level] which required the application of critical thinking whilst searching for information online' (IEA, 2014; Microsoft, 2019, p. 4).

## Anticipating trends and emerging issues

### Necessity to build '21<sup>st</sup> century skills'

A look at recent developments in the labour market has provided strong evidence that specialised ICT skills will become extremely important in the future. Technological skills are very specific and include knowledge of new technologies like blockchain, and the ability to analyse complex data, including the development of artificial intelligence. However, these skills will only be needed in small numbers (Kirchherr et al., 2018), whereas another set of skills is mentioned across the board by various stakeholders. These competences, often coined as '21st century skills', can be categorised as non-cognitive and are human, meta, and soft skills. They include abilities that machines and artificial intelligence hardly or not at all possess but humans excel in, such as **creativity, problem-solving, critical thinking, originality, emotional intelligence and collaboration** (EPSC, 2017, p. 7; Microsoft, 2019, pp. 3–4; Park, 2019, p. 4; World Economic Forum, 2018, p. 12). People with these skills will be increasingly sought after because they can shape and advance digital transformation and the general progress of society and innovations. Furthermore, the ability to manage stress and change, namely resilience, adaptability, leadership and flexibility, is a valuable long-term skill to master in order to be prepared for future developments (Hoell et al., 2018, p. 8). Schools should strive to teach these skills because they enable students not only to complete their school careers, but also to manage their lives.

## 2.4.4. Lifelong learning

### Setting the scene

The idea that learning is a lifelong process is not new and was already promoted by the EU when proclaiming in 1996 a year of lifelong learning and declaring that lifelong learning not only 'enhances long-term employment prospects' (European Parliament and the Council of the European Union, 1995; emphasis added), but also strengthens values such as solidarity, tolerance and democratic participation.

As the digital transformation accelerates changes and volatility in the working world, informal and lifelong learning becomes more relevant. **Current formal, initial education needs to be supplemented with various learning opportunities throughout a career.** The European Political Strategy Centre considers lifelong learning as one of the '10 trends transforming education as we know it' (2017, p. 5).

### Significance and growing popularity of lifelong learning

In addition to adapting school curricula and vocational education (VET) to better prepare future graduates for the world of work and to reduce and prevent skills mismatches, **the current workforce must also be included in the change process.** This way it can be guaranteed that the full potential of employees will be exploited, that none will be left behind due to age or education level and that the productivity of companies and the economy in general will be maintained. This need for upskilling and reskilling must be embedded both institutionally into policy frameworks and intellectually in the way of thinking of employers and the population because shortcomings and future skill gaps cannot be filled only by new recruitments. Employers surveyed by the Centre for



the New Economy and Society of the World Economic Forum 'estimate that, by 2022, no less than 54 % of all employees will require significant reskilling and upskilling' (2018, p. 12).

The attitude towards lifelong learning is already changing and has two main drivers: on the one hand, the young generation is striving for personal fulfilment and development, on the other hand they feel pressure to improve their knowledge, skills and competences to reinforce their employability. The findings of the regularly conducted adult education survey (AES) (Eurostat, 2016) confirm these developments: in the first survey in 2007 just over 35 % of respondents aged 25 to 64 years stated that they participated in formal or non-formal education or training in the twelve months prior to the interview. In 2011 the share had reached over 40 % and further increased to 45 % in the most recent survey of 2016. **This increase is possible in particular because of the distribution of digital applications.**

Massive Open Online Courses (see section 2.1.2) and other online platforms as well as video sharing websites offer new learning opportunities as they enable adult learners to flexibly organise their courses and learn independently of time and place (European Commission, 2019c). They supplement the traditional offerings and allow a wider variety of people to access further education for free. This is particularly important in Member States that have no separate institutions for upper secondary education catering primarily for adults. In many Member States, digital learning programmes for adults are mostly local and/or privately funded initiatives. Only 6 states provide comprehensive coverage and publicly subsidised large scale programmes. This means that increasingly more training is taking place outside of formal settings and in the free time of the employees (European Commission, 2016).

#### Implications for employers and society

Even though **investments in continuing vocational education and training** (CVET) can also benefit employers by boosting productivity, reducing recruitment costs, improving attractiveness and ensuring better diffusion of in-house expertise, they have to bear the costs such as fees, employees' time away from the job and the expenses of dedicated spaces and learning materials (EPRS, 2019). Thus, enterprises with over 250 employees offer more training opportunities than small and medium-sized enterprises (SMEs). The expected return on investment for reskilling and upskilling might also be the reason to not provide further training for older employees, but to focus on the younger generation.

However, the voluntary nature of continuing education harbours the **danger of social disparities**. Member States with a lack of further education opportunities and a bad performance in the Digital Economy and Society Index (DESI) show the lowest rates of participation. In addition, irrespective of a country's overall participation rate, employees with a high level of education are demonstrably more likely to pursue further training and education than middle- or lower-level skilled workers (Colebrook et al., 2015, p. 36; OECD, 2019a), which widens the skill gap and prevents progression in the careers of the disadvantaged. The EU's education and training strategy, ET2020 (Council of the European Union, 2009, p. 2) is attentive to this issue and promotes the strategic framework to its Member States by facilitating a network of national coordinators to exchange best practices on the online platform EPALE ('Electronic Platform for Adult Learning in Europe') (European Commission, 2019b). Another platform, the Lifelong Learning Platform (LLLP), strives to strengthen the dialogue between civil society organisations and public authorities (LLLP, 2015).

#### Anticipating trends and emerging issues

Despite various programmes in the EU, the continuing digital transformation and the increasingly ageing population caused by the demographic change prompts experts to request more initiative from policy-makers. A proposal from the Think20 Engagement Group, consisting of think tanks from the G20 countries, refers to **a better integration of companies into further education and**

**training ecosystem'** (Park, 2019, p. 7). Especially SMEs could benefit from supporting initiatives, as they often have difficulties in motivation and funding for lifelong learning (EPRS, 2019).

#### Certification of competences

Another issue that has to be addressed is the need for **systems of validation of non-formal and informal skills**. The formal qualifications mismatch (see section 2.4.3) could possibly be reduced, because 'ESJS data reveal that a considerable share of the working population already possesses the skills needed by their jobs, even if these are not evident from their formal qualifications.' (Cedefop, 2018a, p.25). Especially competences acquired online need recognised procedures and certification. The European 'YOUTHPASS' (Erasmus+, 2019), a recognition tool for non-formal and informal learning in youth projects, is a good example of such initiatives. Similarly, successfully completed lifelong learning courses and activities can be gathered and certified within the European credit system for vocational education and training (ECVET) (ECVET, 2019). This system is linked to several other European transparency and recognition instruments (the main ones being the European quality assurance reference framework in VET (EQAVET) and the European Qualifications Framework (EQF)). Some Member States already offer modular programmes and alternative routes to higher education, which could be standardised and expanded (EPRS, 2019).

In conclusion, the goals that were set in ET 2020 are still relevant and need to be further improved and approached collaboratively with all important stakeholders. These goals include (Council of the European Union, 2009, p. 3):

- more flexible learning pathways,
- better transitions between the various education and training sectors,
- greater openness towards non-formal and informal learning, as well as
- increased transparency and recognition of learning outcomes.

### 3. Concluding assessment and policy options

This section consolidates the strengths and weaknesses, opportunities and threats (SWOT) for each of the four main stakeholder groups as identified by the preceding literature review. This SWOT analysis builds the basis for the subsequent list of policy options, of which we discuss the four most pertinent in more detail.

#### 3.1. Strengths, weaknesses, opportunities and threats for education in the digital age

##### Policy-makers and public administration

Our analysis of the role of policy-makers and public administration for education in the digital age focused on two interconnected aspects: digital education policies and the provision of digital infrastructure.

With regard to digital education policies, policy-makers have increasingly started to focus on 'soft factors', such as the quality of learning, teacher training, the changing role of the teacher and student competence building – as opposed to 'hard factors' such as broadband access and computers in schools. This clearly constitutes both a strength of current policy and an opportunity for the future, as it increases the chances of pedagogically meaningful applications of technology and value-centred education. At the same time, neglecting 'hard factors' such as up-to-date technological infrastructure in schools constitutes a certain threat as functioning infrastructure will continue to build the basis for digital education.

With regard to the provision of digital infrastructure, the fact that access to infrastructure is relatively high constitutes a strength. At the same time, discrepancies in terms of infrastructure continue to exist between European countries and regions, constituting a weakness. Platform and cloud solutions, open educational resources and massive open online courses offer opportunities as affordable and versatile instruments for re- and upskilling, including for individuals with educationally and financially disadvantaged backgrounds. The danger exists, however, that such resources will be mainly used by individuals with already high intellectual capital.

##### Students

As evident from the analysis, digital skills among the young generation are relatively high when considering the EU-average (E-28: 83 % of individuals aged 16 to 19 possess at least basic digital skills and 57 % possess above-basic digital skills), constituting a current strength in terms of the state of digital education in Europe. At the same time, persistent **differences in the level of digital skills depending on educational background, age, gender and country constitute critical weaknesses**. For example, while, in Finland, 94 % of individuals aged 16 to 19 possess at least basic digital skills, whereas only 52 % in Romania do so. The possibility exists that those students who lag behind will have a much harder time in tomorrow's labour market – and tomorrow's labour market will lose important talent.

Furthermore, while, among the young generation, digital skills differ only negligibly between genders (constituting a strength), girls are by far less likely to turn their digital competences into a career (a current weakness). As outlined in the analysis, a continuously low number of women enrolling in ICT-subjects and only few women taking up ICT-related jobs constitutes a clear threat for an already extremely tight (digital) labour market.

At the same time, utilising the female potential for the digital labour market constitutes a huge **opportunity**. Companies seeking to fill open ICT positions often offer high career flexibility and

work-life balance, constituting opportunities for those women (and men) for whom these factors matter.

In terms of future opportunities and threats, we further discuss career guidance and the promotion of computational thinking and entrepreneurship through education. Through career guidance, unrealistic expectations of the labour market can be corrected, the student's horizon that is restricted by social and personal characteristics can be broadened, and their talents, interests and personalities can be matched with fitting career paths. Hence, the greatest **opportunity** and reason to strengthen career guidance in the context of an increasingly flexible and fast-changing labour market is that it brings significant economic and social benefits for the individual as well as for society as a whole.

To enable students to better understand and navigate the digitalised world they live in and will live in, it would prove beneficial if curricula included computational thinking. Computational thinking refers to aspects such as abstraction and generalisation, algorithmic thinking, as well as debugging, problem decomposition and general processes of problem analysis. The current **integration of computational thinking in curricula** varies strongly across EU Member States, and to date is mostly not an explicit part of school curricula. **A critical challenge for introducing computational thinking into curricula is to ensure that teachers acquire the appropriate knowledge.**

Entrepreneurial skills such as creativity, critical and strategic thinking, problem solving, collaboration, negotiation, courage and perseverance constitute opportunities that can help students successfully master both academic and professional careers in a digitalised society. Furthermore, a basic understanding and interest in entrepreneurship can help **promote the establishment of start-ups across Europe.**

### Educators and trainers

Our analysis underlines that educators, trainers and teachers play a pivotal role in shaping education in the digital age, and thus need more support and encouragement through training and professional development to accomplish this purpose.

A **strength** regarding educators and trainers is the fact that there is currently a range of digital applications which, if used in a pedagogically meaningful way, can truly support digital education and teaching. However, only a small proportion of teachers exploit the potential of the available opportunities, which is currently a major **shortcoming** in many European countries.

This circumstance is related to the current sub-optimal state of teacher training and professional development in several EU countries. **The vast majority of teachers do not or only sporadically participate in professional development focused on digital education**, which constitutes a major threat to education in the digital era. Another threat concerns the teachers' future role in digital education. Due to their limited participation in professional development, teachers do not sufficiently adopt new forms of teaching, but instead use new technologies in combination with outdated teaching concepts.

However, innovative concepts such as eTwinning offer impressive **opportunities** to overcome the existing shortcomings at least on a voluntary basis. By participating in such programmes with exchange and cooperation opportunities, the confidence of teachers in the use of digital technologies is strengthened.

Great **potential** for teaching in the future comes from technologies such as augmented and virtual reality, blockchain and artificial intelligence. Due to their interactive formats of augmented and virtual reality in realistic settings, these applications can increase learners' motivation and the retention of learning content. Applications of blockchain in educational contexts allow easy access from anywhere, and information such as certificates can be retrieved immediately and be further

processed by requesting institutions. A clear **opportunity** of artificial intelligence is the overview and prediction it generates for students' school performance and the possibility to personalise learning according to their competence levels ('smart learning').

However, the implementation of artificial intelligence should be thoroughly controlled as it allows **monitoring of learners' behaviour** that goes far beyond performance tracking in learning apps. The increasing relevance of artificial intelligence in learning contexts and the increasing amount of data accumulated from students raise questions about data protection, ethics and the role of policy and politics. National or EU-wide guidelines on the ethical use of artificial intelligence in learning contexts could become necessary in the near future.

## Businesses and employers

The preceding analysis demonstrates that the digital transformation affects the working world at various levels. On the one hand, new technologies influence how and where people work; on the other hand, the expectations of employees and their skills will change drastically.

The main **strength** and a current trend, namely the flexibilisation of work (World Economic Forum, 2016, p. 8), is overshadowed by predicted disruptions in the labour market. One important objective for policy-makers requested in the reviewed literature is the **revision of employment regulations** in order to adapt to the new, flexible forms of work. Employees in non-traditional employment settings could otherwise become disadvantaged.

The labour market currently faces various challenges and **weaknesses** associated with the digital transformation. **Experts** predict a significant decrease in jobs for workers with mid-level qualifications through automation and artificial intelligence and highlight the increase in demand for higher education, digital competences and transversal skills. Unless a comprehensive strategy for upskilling and reskilling is implemented, employees will lack the necessary qualifications to perform at work. This qualification mismatch also applies to graduates, but mostly in the form of over-qualification. **Another weakness** is the related skill mismatch. Whereas the demand for ICT knowledge increases constantly, not enough students decide to study the corresponding subjects. This results in a skill shortage, depicted as hard to fill vacancies, which hinders companies in their growth and innovative developments.

One **opportunity** to approach these challenges is the early identification of skill requirements and the matching of demands of the job market with the interests and educational choices of students by promoting ICT career paths.

Furthermore, digital technologies enable adult learners to flexibly organise their courses and learn independently of time and place.

Even though the EU offers various tools for validation of non-formal and informal education and training, a coordinated system for all Member States, all education levels and different (online) education and training providers, is a great **opportunity** to make the validation easier. Furthermore, it could generate more transparency and awareness, and enable learners to really profit from the already existing flexibility, because universally recognised certificates facilitate mobility across companies and occupations as well as between countries.

However, the voluntary nature of continuing education harbours the **danger of social disparities** as employees with higher education are over-represented while middle- or lower-level skilled workers participate less often, which widens the skill gap and prevents progression in the careers of the disadvantaged.

Figure 10 – SWOT as basis for policy options

	Policy-makers	Students	Educators and trainers	Employers and employees
Strengths	<p>Provision of digital infrastructure for school has reached a good level when looking at European averages</p> <p>Policy work increasingly focuses on the 'soft factors' such as quality of learning, teacher training and student competence building.</p>	<p>Strong affinity and experience in using digital technologies.</p> <p>Digital skills differ only negligibly between genders among the young generation.</p>	<p>New methods of professional development are promoted by initiatives such as eTwinning.</p>	<p>Flexibility of work and lifelong learning.</p> <p>Various tools for identifying future skill requirements.</p>
Weaknesses	<p>Disparities between regions and countries persist in terms of the provision of digital infrastructure for schools</p>	<p>Digital skills depend on educational background, age, gender (in older generations) and country.</p> <p>Disparities in the beneficial and critical usage of digital technologies depending on socio-economic background.</p> <p>Girls are far less likely to turn their digital skills into a career.</p>	<p>No systematic professional development programmes on education in the digital age for teachers, often only on a voluntary basis.</p> <p>Programmes are often not regularly evaluated and not necessarily built upon scientific evidence.</p>	<p>Youth unemployment and over-qualification at the same time.</p> <p>Skill mismatch regarding ICT.</p> <p>Non-formal and informal skills are often not sufficiently recognised and formally approved.</p>
Opportunities	<p>Providing platform and cloud solutions, open educational resources and massive open online courses would offer opportunities as affordable and versatile instruments for re- and upskilling.</p>	<p>Capitalise on the existing digital skills of girls.</p> <p>Strengthening career guidance, computational thinking and entrepreneurship education would bring significant economic and social benefits.</p>	<p>Personalised learning contexts could improve student motivation and retention and shift the teacher role from instructor to 'learning guide'. Teachers' resources could be freed up for pedagogically more valuable tasks.</p>	<p>Creation of new occupations.</p> <p>Lifelong learning with digital applications.</p>
Threats	<p>If up-to-date technological infrastructure is not broadly available in educational contexts, students cannot be sufficiently prepared for the challenges of tomorrow's labour market.</p> <p>A lack of interoperability and standards compliant with European non-discrimination and data protection laws</p>	<p>If disadvantaged students do not receive sufficient support, the 'second digital divide' will widen, youth unemployment will rise and a part of the young generation will be left behind.</p>	<p>Insufficiently trained teachers cannot prepare students for the challenges of tomorrow's jobs.</p> <p>Issues concerning data protection and discrimination by algorithms could arise from new teaching software.</p>	<p>Possible job substitution and job polarisation.</p> <p>If the current and future workforce is not adequately trained and educated, Europe will lose its global competitiveness.</p>

### 3.1. Policy options at a glance

On basis of the preceding SWOT analysis and taking into account relevant policies in place and proposals under discussion, the following list of policy options outlines ways to bring education in Europe to the forefront of discussions on the digital transformation, prepare today's students for their future life and work, and thereby both safeguard Europe's global competitiveness and social inclusion across all segments of society.

#### Policy-makers and public administration

- Provide information on best practice examples to improve the dissemination and adaptation of success models across Europe.
- Support the development of clear guidelines on data protection issues with a focus on digital education.
- Develop non-bureaucratic procedures for approval processes for the use of educational software and other digital tools while ensuring the scientific foundation of these tools and compliance with standards of data protection, non-discrimination and the like.
- Establish a fund which promotes the development of standardised European educational software (particularly open educational resources) that is open to third-party providers.
- Evaluate how far the European Social Fund (ESF) could invest in digital school infrastructure in regions that lag behind.

#### Students

- Promote the development of harmonised, ambitious standards for digital education across the EU. Approaches could include the establishment of a European network or platform and the support of cooperation projects bringing together academia and practitioners from different European countries.
- Encourage Member States to put stronger focus in school curricula on the transmission of soft skills that are of specific relevance for the digital age, such as self-management, entrepreneurship education and computational thinking.
- Organise a comprehensive career guidance system in order to prepare students for a more flexible and volatile job market that requires self-initiative and the willingness for lifelong learning.
- Promote cooperation between employers, schools and other supportive actors (e.g. coding clubs) to help disadvantaged students without extensive social networks.

#### Educators and trainers

- Encourage Member States to include and standardise digital education in both basic and continuous teacher training. The encouragement could for example take the form of soft coordination (e.g. publication of rankings). As it is crucial to systematically develop and mainstream educators' pedagogical digital competences, possible mandatory participation in regular digital competence training for teachers should be discussed.
- Enhance and mainstream innovative ways of professional development for teachers, including 'peer learning', i.e. teaching and learning by and with teachers, and massive open online courses (MOOCs).

- Introduce digital coaches in schools that assist teachers in using digital tools, and in developing and applying appropriate pedagogical methodologies.
- Enhance support for the development of digital concepts and media development plans. Create and publish a knowledge base for using digital technologies in pedagogically meaningful ways.

### Employers and employees

- Promote the creation and recognition of ICT bootcamps (and possibly ICT bootcamps for women), including grants for lateral career movers. This would make it easier for individuals to enter ICT careers at a later stage in their career, and be a remedy for an extremely tight ICT labour market. Employers could function as potential sponsors.
- Enable closer cooperation between the education system and the labour market in order to mediate requirements of occupations, expectations of students and options to adjust school curricula.
- Establish a coordinated system for the validation of non-formal and informal education.

### Research

- Ensure that educational policy in the digital age becomes and remains evidence-based. Establish rigorous accompanying science and regular evaluations of the efficiency and effectiveness of teaching methods and teacher training a matter of course.
- Ensure that results from publicly funded research on education in the digital age are made publicly available so that all concerned stakeholders, including governments, public administration, schools, teachers and parents can build on existing evidence.
- Facilitate and promote close cooperation between (applied) researchers on digital education, specialised educators (coaches), teacher education and policy-making. Adjust existing research funding so that such close cooperation and exchange can be achieved.
- Foster knowledge transfer from research to practitioners and policy-makers.

## 3.2. Zooming in: recommended policy options in more detail

In the field of education, most competences lie with the Member States, and the implementation of change hence depends considerably on national and sub-national players within the system, including governments and public administration down to schools and teachers. Therefore, the most appropriate option for the European Parliament is to promote policy that actively supports stakeholders and competent authorities in their efforts and that consolidates individual projects and initiatives. In this spirit, we present in the **following the most pertinent policy options from the preceding initial list of policy options**. We recommend four comprehensive instruments: incorporating education in the digital age into existing and future research frameworks to further promote evidence-based policy, supporting the creation of a knowledge-sharing platform for education in the digital age, simplifying and harmonising the recognition and validation of lifelong learning, and offering a harmonised, yet versatile cloud solution for the provision of high-quality (open) educational resources.

### Incorporating education in the digital age into existing and future research frameworks to further promote evidence-based policy

Digital technologies, from hardware such as computers, tablets and smartphones to teaching and learning software, are increasingly entering the education sector. The advantages are clearly



discernible, but disadvantages and uncertainties are also repeatedly discussed. Scientific efforts need to be accelerated to resolve the insecurities surrounding the use of digital technologies in education and to identify the drivers and challenges for pedagogically valuable digital teaching and learning. Policy decisions should build on the resulting scientific evidence.

Several studies (PISA, ICILS, PIAAC) already incorporate the analysis of digital competences present in the population and among students. In addition to diagnosing the outcomes, new processes of teaching and learning should be examined more extensively. The suggested research should cover the following topics:

- Teaching methods for the digital age, including the question of which type of exposure to digital media is meaningful and pedagogically fruitful at which age and under what circumstances.
- Impact and useful applications of artificial intelligence in education, including personalised learning content, protection against algorithmic discrimination and data protection issues.
- Applied research to guarantee the scientific foundations of teaching software.
- Acceptance research on how teachers can be encouraged to adjust teaching methods to the requirements of the digital age.

We recommend expanding the current fairly sporadic funding on technologies for learning implemented in Horizon 2020, the EU funding programme for research and innovation. Similar to the efforts under the European Social Fund (ESF) to improve education and training in general, research specifically on educational technologies should be intensified. A particular focus should be placed on applied research, the transfer of results from academia to teacher training and schools and the development and communication of good practice projects.

To ensure that future education in the digital age can build on scientific evidence and the latest scientific standards, results from publicly funded research should be made publicly available to all concerned stakeholders, fostering knowledge transfer from research to both practitioners and policy-makers. A means for supporting this knowledge transfer could be a knowledge-sharing platform for education in the digital age, as presented in the following.

### Supporting the creation of a knowledge-sharing platform for education in the digital age

Numerous stakeholders and a multitude of initiatives across Europe have so far dealt with the challenges of, and developed solutions for, education in the digital age. However, the vast knowledge gathered by the respective national and sub-national stakeholders is not to date accessible in one place.

A way of making existing expertise, experiences and success stories accessible to all relevant stakeholders would be the establishment of a platform for transnational, long-term coordination and dialogue on education in the digital age. Creating such a knowledge-sharing platform could greatly improve the dissemination and adaption of success models across Europe.

The European Commission's Smart Specialisation Platform<sup>19</sup> could serve as a model. This comprehensive platform incorporates several functions in one central location and was conceived within the European Commission's cohesion policy (operative from 2011 onwards). The platform follows a bottom-up approach, signifying that countries and other stakeholders contribute their visions, demands and projects and jointly approach and solve them. The platform assists EU

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<sup>19</sup> <https://s3platform.jrc.ec.europa.eu/>

countries in implementing their Research and Innovation Strategies for Smart Specialisation (RIS3), i.e. in identifying and exploiting their respective strengths and diminishing their weaknesses to accomplish long-term innovation and growth.

Following the example of the Smart Specialisation Platform, the proposed knowledge-sharing platform for education in the digital age could:

- provide information, methodologies, data, expertise, good practice examples and advice guidance;
- align the resources and strategies of different stakeholders;
- promote a collaborative environment with mutual learning, transnational cooperation and innovation partnerships;
- incorporate helpful tools, like wikis, scoreboards, maps, catalogues, visualisations, and communities.

### Simplifying and harmonising the recognition and validation of lifelong learning

Digital technologies foster new opportunities for lifelong learning that go well beyond the traditional education system. While several systems and frameworks for approving achievements from lifelong learning are already established at the European level, existing systems and frameworks could go further in terms of transparency, visibility and reputation. In consequence, lifelong learning still tends to be underappreciated, underestimated and insufficiently validated despite its tremendous significance in times of major economic change as induced by the digital transformation.

We recommend promoting the coordination of existing structures into a single system including a simplified and harmonised certification process aligned with all major stakeholders in the education sector, including new digital learning providers and public administration in the Member States. The harmonisation of secondary education resulting from the Bologna Process could serve as an example.

By harmonising and simplifying its recognition, both the value and quality of non-formal education could be increased, the reskilling and upskilling urgently necessary in the digital age could be accelerated and workers' skills and the labour market's necessities could be better and faster matched.

### Offering a harmonised, yet versatile cloud solution for the provision of high-quality (open) educational resources

An important objective of education in the digital era is to incorporate already developed and available technologies for learning and teaching into everyday school life. Despite regular use in private leisure time, many teachers shy away from using digital learning resources in the classroom. To solve this issue, educators need to have easier access to supporting and complementary learning materials and methods. Likewise, suitably selected contents, in the form of wikis, learning videos, learning games, tasks and tests are beneficial for students to learn independently, to fill knowledge gaps and to pursue individual interests.

The concept of open education is already being explored by some regions, universities and networks across the EU. However, these initiatives cooperate with a variety of IT providers and partners (e.g. textbook publishers) resulting in an opacity of standards and a lack of interoperability.

One way to support educators and students in integrating digital technologies into the learning process would be to reduce opacity by supporting harmonised, yet versatile standards and interoperability. An initiative for open science organised by the European Commission, the European Open Science Cloud (EOSC), is expected to become operational in 2020 and could serve

as a model.<sup>20</sup> The EU could contribute by providing the necessary cloud infrastructure in compliance with European data protection, copyright laws and values, guaranteeing standards, interoperability, user-friendly operation and independence from commercial profit-oriented producers.

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<sup>20</sup> <https://www.eosc-portal.eu/>

## 4. Annex – methodology of the literature review

In the following, we briefly describe our methodological approach with a specific focus on the literature review.

To guarantee that the literature we identify covers the most relevant issues, we employ a systematic approach and rigorous methodology, which is laid out in the following. Our methodology combines a number of different strategies.

- (1) First, we define a list of the relevant search terms. We start from the concept of 'digital education' and define both synonyms and adjacent terms. We refine this list in an iterative process, where the results we receive from applying the search terms to the body of literature decide whether it is necessary to adjust the terms or include additional ones.

The following search terms were used:

- 'future skill', '21st century skills', 'digital skills', 'digital literacy', 'STEM/skill gap'
- 'digital + school', 'digital + classroom', '(digital) school / classroom 2030', '(digital) school / classroom 2050', '(digital) school / classroom foresight'
- 'digital + learning', 'digital + training', 'digital + education', 'EdTech'
- 'AI + learning', 'AI + training', 'AI + education'

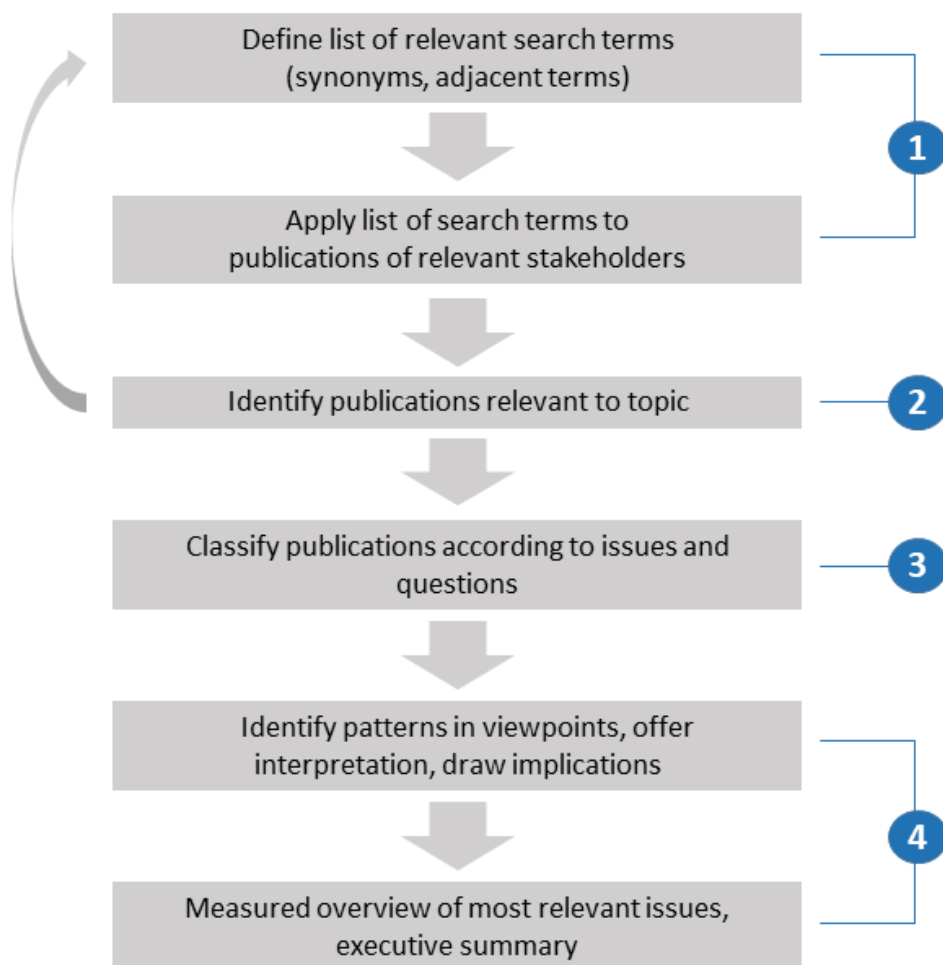
These search terms were used as is and in combination with 'Europe', 'EU' and 'OECD'.

- (2) Second, we use this list of search terms to screen all publications by the most relevant stakeholders for content relevant to digital education. This includes publications and strategy papers by the European Parliament, the European Commission, and other EU institutions, as well as official publications by the governments of EU member states. It also includes publications by international organisations such as the OECD, UN, World Bank and the International Labour Organization. We also consider publications by relevant think tanks and consultancies. To make sure we include both official statements and innovative, not yet official viewpoints, we also scan blog posts and conference proceedings relevant to the subject.
- (3) Once we have defined the relevant body of literature, we classify, in a third step, the literature according to the topics and questions we want to answer. We use a classification of issues according to stakeholders, namely (a) policy-makers and public administration, (b) educators & trainers, (c) students & parents, and (d) businesses & employers.
  - a. For example, policy-makers and public administration in the Member States are responsible for providing and encouraging policy frameworks and enabling technologies such as broadband connectivity. Issues that concern first and foremost policy-makers include the following: *Is the digital infrastructure sufficient and generally accessible? What policy measures are taken to diffuse security concerns such as privacy and data protection?* Regarding educators and teachers, some of the relevant questions include: *How are digital tools and technologies used to teach basic skills (such as numeracy, literacy, etc.) and traditional core subjects? What impact will digitalisation have on the teaching profession and the position of teachers?* Regarding students and parents, questions include: *Will these new technologies and education modalities benefit everyone, especially those who need it most?* Issues regarding businesses and employers are: *Have the skills sought by employers evolved over time? How can the connection between education and employment be enhanced?*
  - b. We further define sub-classifications along the process. Classifying the literature implies that we dive deeper into each publication and extract the information

relevant to each topic. For extracting and classifying information contained in the literature, we employ the program Citavi, a reference management and knowledge organisation software. This step results in an overview of all relevant statements made on each topic.

- (4) In a last step, we interpret and assess the classified body of literature. This signifies that we aim at identifying commonalities and patterns within the statements made on each topic. For example, do some actors agree that the most effective measure to improve digital literacy is to provide the necessary infrastructure while others disagree? What are their respective justifications? Is there a pattern in which type of actor assumes which position? From this, we derive a measured overview of the most relevant issues and viewpoints, and a calibrated summary regarding both the current state and the (expected and possible) future of digital education. This last step also allows us to increase the reliability of our results by triangulation, meaning that several different and independent sources support a statement. In addition, we take care that a good balance between sources is guaranteed.

Figure 11 – Structured procedure and methodology for horizon scanning and literature review



Source: VDITZ.

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This study deals with the political and educational implications that arise from the technical developments in the education sector and the digital transformation of the labour market and society as a whole. As teachers' traditional roles are being challenged, new content and digital methods of teaching are being added, and new technical and 'soft' skills are gaining in importance, education today needs to prepare students for changing tasks and roles both in the labour market and as European citizens.

The study presents policy options for (European) policy-makers on the basis of a thorough analysis of current strengths and weaknesses, as well as future opportunities and the threats to education in the digital age.

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