EIT Digital — Makers & Shapers

THE FUTURE OF EDUCATION
FOR DIGITAL SKILLS

CONTENT

EXECUTIVE SUMMARY

The digital transformation, accelerated by the COVID-19 induced digital surge of the past two years, requires a skills revolution in Europe. It is a challenge and opportunity where matters of inclusion and growth converge with one another. Europe needs educational systems fit for the digital age, alongside supplementary programs to train and retrain that part of the adult population which has long left their studies behind. It is a two-sided challenge, concerning both basic digital skills, as part of today's understanding of literacy, and specialised skills needed for European firms and organisations both to innovate in Key Enabling Technologies (KETs) such as Artificial Intelligence (AI) or Internet of Things (IoT) as well as stay safe and secure bearing the needed cybersecurity specialists. The importance of these two dimensions (basic digital skills and digital specialism) has been underscored by the ambitious targets that the Digital Compass (European Commission, 2021) set for 2030 in the domain of digital skills as given in the box below.

DIGITAL COMPASS TARGETS FOR DIGITAL SKILLS
- **Target #1**: 80% of adult population with basic digital skills.
- **Target #2**: 20 million employed digital specialists in the EU.
- **Target #3**: convergence of men and women in digital specialist employment.

A recent Monte Carlo simulation shows that by 2030 Europe will reach neither of the key targets 1 and 2 set in the Digital Compass (Codagnone et al., 2021, pp. 48-49). Without an exogenous jolt in the form of more investments and/or innovations in the supply side, the current trajectory indicates that by 2030 there will be only 64% of the population with at least basic digital skills (short 16 percentage points from the target) and only 13.3 million employed digital specialists (short 6.7 million from the target).

In this report we tackle the issues of digital skills and digital specialism considering the supply of broadly defined education and training presented by both public and private institutions, identify the main gaps, and extract from them foresight scenarios.

The main trends in the public sector offering are summarised as follows:

- At the primary and secondary level of education, digital competences are taught as a separate well-defined scientific discipline only in few Member States. Most of the time digital skills are a cross-curricular theme or are integrated and applied in other subjects.
- Several initiatives addressing computational thinking in both formal and non-formal settings have been organised, both at national and international levels, to complement the lack of provision in computing and informatics education (only in six countries at primary educational level).
- Teachers of primary and secondary schools urgently need to be retrained and upskilled. This is a key aspect to offer effective digital education at all levels. However, this is reflected in recommendations for initial teacher training in only half of European education systems.
- On average, European institutions are slow at changing their curricula and when they do, the approach remains very traditional and not adapted to the dynamism of the labour market needs, except for some good practice cases of programmes combining public and private sector.
- There is a very limited and fragmented offer of new specialised Master programmes in Key Enabling Technologies (KETs) in European universities that, with only a few exceptions, are not at the top position of university ranking for KETs.
- European universities on average are also not very responsive to the need of re-skilling and upskilling the adult population.

The main trends in the private sector offering are summarised as follows:

- There are several initiatives from non-profit organisations that mostly target the lower end of very underprivileged groups, providing them short crash courses for minimum skills to get by in their daily life.
- Private-public partnerships are becoming increasingly important to ensure that the courses and training offered are aligned with industry needs. Universities cooperating with industry and including industry expert knowledge/input into their curricula can benefit from prioritised public funding.
- Collaborations between governments and industrial partners at the local level are also increasing in Europe. Private actors benefit from this in different ways. For instance, technology companies can offer a valuable contribution to high-tech skills development initiatives by providing free access to knowledge assets and technological equipment. Furthermore, private-sector involvement can be driven by the human capital needs of high-tech employers.
- There are several private organisations that launched their own independent institutes, which normally provide a digital certificate at the end of a professional program.
- Specific methods are employed by private organisations for high-tech skills development. These range from online and classroom curricula to more innovative methods, such as educational laboratories and online platforms that connect supply and demand in areas of the labour market that pertain to high-tech innovation.

Accordingly, four main gaps are identified:

- Clear fragmentation across Europe in the approach towards digital competences at primary and secondary level educational system.
- On average European institutions at the university educational level for specialised digital skills are slow to change their curricula. When they do, the approach remains very traditional and not adapted to the dynamism of the labour market needs.
- Lack of private sector supply addressing the middle of the digital skills scale. The NGOs initiatives, in fact, mostly target the lower end of very underprivileged groups provided with short crash courses that give them the minimum set of skills to get by in their daily lives.
- The offerings of the tech giants and of other specialised private sector establishments tend to focus more narrowly on their own labour market needs and to be exclusive as attendees need to pay for themselves or be funded.

From the above discussion four extreme scenarios are developed based on different future evolutions in both public and private sector offerings of providing general and specialised digital skills: 'Digital Selectiveness' (where the public sector offering is more responsive to technological trend and market needs, while private offering remains narrow in scope and target), 'Digital Plenitude' (where public sector offering is responsive and private sector offering is broader in both scope and target), 'Digital Widening' (where public offering remain traditional and unresponsive and this is partially compensated by the broader private offering), and 'Digital Deprivation' (where both offerings score on the more negative pole of the dimensions). Only the 'Digital Plenitude' scenarios manage to both broaden digital inclusion and produce the digital specialisms needed for boosting innovation and productivity. Based on these scenarios, the report concludes that to move toward the more favourable scenario three main changes need to take place:

1. **The entire European public education system, from primary schools up to universities, needs to urgently modernize the largely outdated digital education programs.** The public offering must reform its curricula both at primary and secondary level, and at university level, by making them more responsive to the changing technologies and labour market needs. This requires organisational and governance reforms to open the systems to partnerships with civil society. As well as tangible investments in connectivity and in new training for both teachers and professors.

2. **The scattered private digital education initiatives should move to a complementary, broader, and better coordinated overall offering of digital skills initiatives.** NGOs should broaden their scope in terms of both the topics and the targets of their training, to also reach the middle level in the scale of digital skills. Tech giants and other private players should provide courses that are not just strictly instrumental to their technological ecosystem. In partnership with local governments and/or public institutions, they should offer scholarships or other financial schemes that would increase the pool of participants to their education offering. For this, new partnerships between educational institutions, businesses, NGOs, and governments are needed.

3. **There is a need for better orchestrated pan-European digital skills initiatives, networks and ecosystems to increase overall quality, efficiency, and effectiveness.** To achieve the digital skill targets of the European Digital Compass in a fair, inclusive and sustainable way there is a need for collaboration at the European level given the huge challenges and costs involved. The emerging trends of pan-EU education initiatives like those of the EIT and the European University Networks should be better coordinated and further strengthened and extended to include the private sector. There is an orchestration role for the European Commission to work in close collaboration with the member states to establish a fair and inclusive digital skills education system across Europe that involves both public and private education providers.

INTRODUCTION

The digital transformation, accelerated by the COVID-19 induced digital surge of the past two years, requires a skills revolution in Europe. It is a challenge and opportunity where matters of inclusion and growth converge with one another. Europe needs educational systems fit for the digital age, alongside supplementary programs to train and retrain that part of the adult population which has long left their studies behind. It is a two-sided challenge, concerning both basic digital skills, as part of today's understanding of literacy, and the specialised skills needed for European firms and organisations both to innovate Key Enabling Technologies (KETs) such as Artificial Intelligence (AI) or the Internet of Things (IoT) as well as stay safe and secure bearing the needed cybersecurity specialists. While 58% of employers say that finding people with the right skills is their number one challenge[1], there are hundreds of thousands of job vacancies that cannot be filled because Europeans do not have the right digital skills[2]. A skills revolution that leaves no one behind and at the same time creates new jobs filling the skills gap that European industries are currently facing is needed.

Digital skills have implications for inclusion and social cohesion, as well as for innovation and productivity. As a result of the COVID-19 digital surge, basic digital skills have become even more important for getting through everyday life, such as being active within society and participating in basic democratic processes. Many public services have moved online entirely. Online transactions and eCommerce have become the norm for the digitally skilled segment of the population. Young people and older adults alike, who lack basic digital literacy, are already digitally excluded from a large array of social, economic, and political activities. Europe runs the risk of seeing digital divides persisting or even increasing in relation to gender, socio-economic background, and differences between urban/rural areas. This is a risk, which is not only related to digital skills, but it is also a matter of effective universal Internet access. (This is yet to become a reality due to geographic location, particularly in primary and secondary schools.) Furthermore, improving digital skills is also important for those employees, who may not be required to be digital specialists, nevertheless, must perform many administrative and operational activities online. It has long been shown by economists that productivity and innovation depend not only on capital and technology, but also on labour productivity. There is a clear complementarity between technologies and human labour. Without digital specialists, KETs will remain an unexploited potential for European firms, with productivity and innovation being foregone. Thus, it is evident that a cohesive, productive, and innovative Europe would greatly benefit from the targets set by the Commission on increasing basic digital skills among the population at large and employing millions of digital specialists in European firms.

In this report we tackle the issues of digital skills and digital specialism by considering the supply of broadly defined education and training presented by both public and private institutions (both firms and NGOs), identifying the main gaps, and extracting from them foresight scenarios. In chapter two, we review the state of the art in the public and private supply of education and training in digital skills. In chapter three, we first identify the main gaps from which we will proceed to the presentation and discussion of four possible future scenarios. These scenarios are assessed in chapter four with respect to key impact dimensions, from which we draw a few key policy implications.

1 Speech by Commissioner Mariya Gabriel at the Online Educa Berlin 2020 (https://ec.europa.eu/commission/commissioners/2019-2024/gabriel/announcements/speech-commissioner-mariya-gabriel-online-educa-berlin-2020_en).

2 Statement made by Nicolas Schmit, Commissioner for Jobs and Social Rights, and reported in "Commission in bid to ensure '70% of EU adults' have digital skills", EurActiv (see: https://www.euractiv.com/section/digital/news/commission-in-bid-to-ensure-70-of-eu-adults-have-digital-skills/).

DIGITAL SKILLS: **DEMAND AND SUPPLY SIDE TRENDS**

THE DEMAND FOR DIGITAL SKILLS: BASIC AND SPECIALISED NEEDS

There are two dimensions of digital skills that are both important for the future social cohesion and prosperity of European countries. One relates to the capacity to simply function within economy and society given the pervasiveness of digital technology, and the second is the specialist digital skills needed by European firms to keep up with digital innovation and the steady disruption of work organisation and processes. The importance of these two dimensions has been underscored by the ambitious targets that the Digital Compass (European Commission, 2021) set for 2030 in the domain of digital skills as reported in the box below.

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Basic digital skills together with universal Internet access are considered in the Digital Compass as defining 'digital citizenship' (European Commission, 2021, pp. 12-13), which is the capacity to actively participate in the economy, society, and democratic processes. The importance of basic digital skills can be gathered by the way such skills have been defined in the Digital Competence 2.0 (DigComp 2.0) framework developed by the Joint Research Centre (see for instance Vuorikari et al., 2016) and depicted in the picture below.

As underscored in DigComp 2.0, digital skills are not just a matter of using given technical tools. Digital skills call for a wide range of cognitive soft skills necessary to search contents and functions, assess and filter them, solve problems, while at the same time be aware of the privacy and security issues involved when being active online.

COVID-19 and related social distancing measures have accelerated a massive and unprecedented digital surge, with radical changes and a heightened need for using digital technologies and media (Guitton, 2020). Even though this has had positive effects, it has also increased the risk that, given this digital surge, new forms of digital divides and inequalities may emerge and take root.

Evidence regarding the impact COVID-19 is having on social health inequalities is already piling up and is intensified for groups which are: less digitally skilled; from low-income households; older adults; homeless populations; and others who are generally being more affected by the crisis (Codagnone et al., 2021, p. 15). Older adults who are frail and (digitally) disconnected, and for the most part live in long-term care facilities, struggle with the double burden of social and digital exclusion. And it must be considered that as of 2019, on the eve of the COVID-19 generated digital surge, while 85% of European citizens used the internet, only 58% possessed minimal basic digital skills (European Commission, 2020a).

As EIT Digital documented in its first report in the series 'Makers & Shapers' (2019): despite much talk about the risk of digital technologies destroying most jobs, full substitution of human work seems unlikely. The observed trend is rather a shift in the
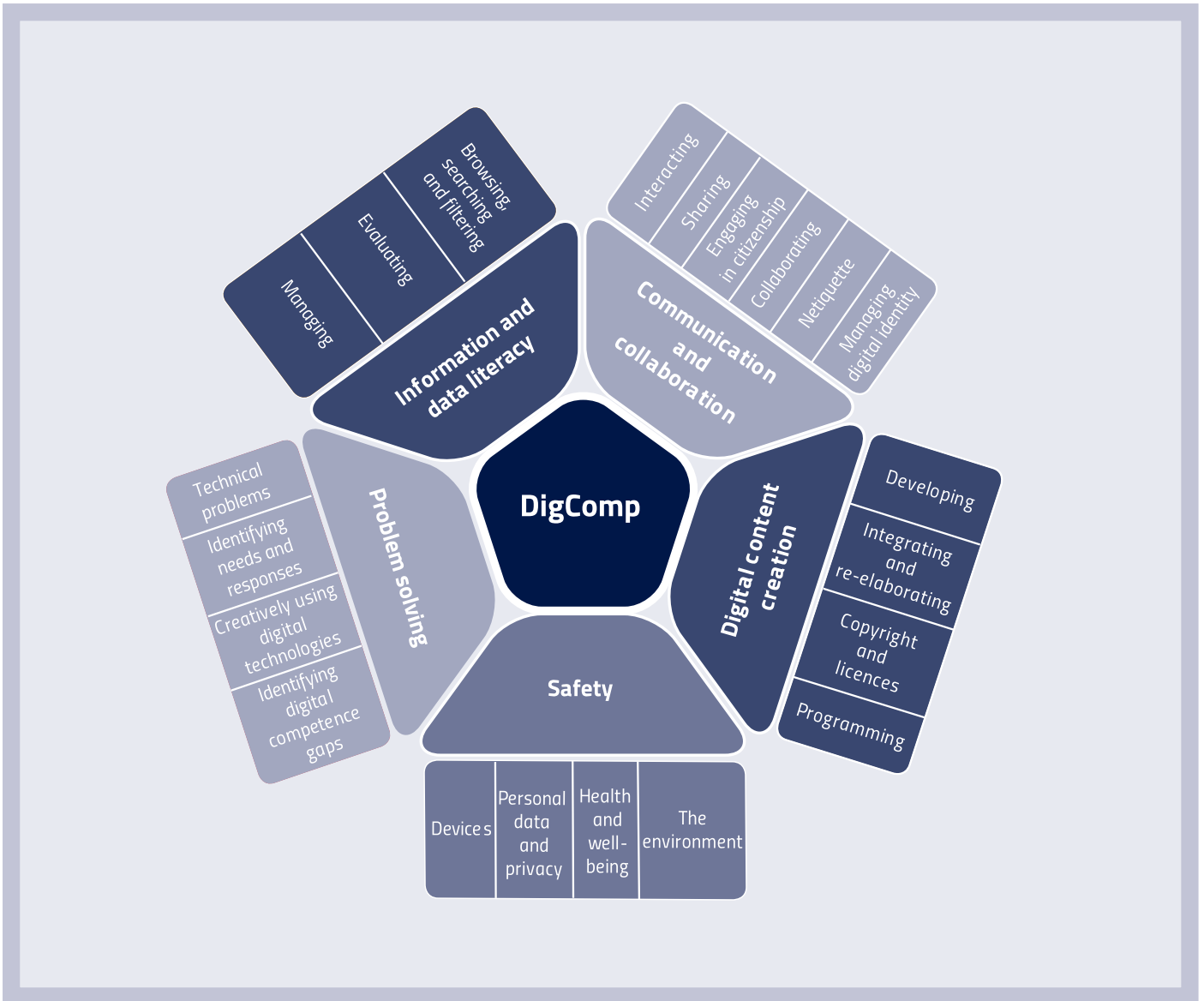
Figure 1 DigComp 2.0. Source: Elaboration on Vuorikari et al (2016)

skill sets required (by businesses), with an increased need for digital specialists and digital skills across the workforce. In a survey conducted by the European Commission (2016a), 90% of employers reported that professionals, technicians, sales workers, or skilled agricultural workers need to have at least basic digital skills. With the speed of technological progress, the existing basic and/or specialized digital skills set quickly becomes obsolete, with new skills being chronically scarce. As of 2018 there were only around 7.4 million ICT specialists employed across the EU, of which 1.7 million in Germany and 1.1 million in France. In 2020, 19% of European enterprises employed ICT specialists (Eurostat, 2021). Out of this percentage, 76% worked for large companies, while only 14% worked in SMEs. Among the enterprises that employ and recruit ICT specialists, 29% of the large ones reported having at least one hard-to-fill vacancy.

This brief contextualization of the state of play shows that both for basic digital skills and for ICT specialists we are still far from the ambitious targets set by the Digital Compass for 2030. Respectively, 58% of the population with basic digital skills versus the 80% target, and 7.4 million ICT specialists employed versus the 20 million target. These are the two key demand side needs that both the public and private supply should respond to.

TRENDS IN PUBLIC INSTITUTIONS OFFERING

The development of students' digital competences is mentioned in almost all primary and secondary curricula of European educational systems. However, unlike other traditional school subjects, this curricular area is not only treated as a separate topic, but also as a transversal key competence. Digital competences are integrated within school curricula in three main ways:

- As a **cross-curricular theme**: digital competences are not a special curriculum subject but are transversal and taught across all subjects in the curriculum. With this approach, students are taught how to use the basic digital tools and devices and all teachers share the responsibility for developing digital competences.
- As a **separate subject**: digital competences are taught as a distinct subject area like other traditional subject-based competences.
- **Integrated into other subjects:** digital competences are incorporated into the curriculum of other subjects or learning areas. This is a more advanced approach that leverages on the potential of digital tools that are applied to other subjects. In this way, students learn how to apply basic digital skills in different contexts.

While digital competences are part of the curriculum in most of EU countries at all three education levels (primary, secondary, and university), eight educational systems[3] do not explicitly include them in their national curriculum for primary education (European Commission, 2019a). Furthermore, two other educational systems[4] also do not explicitly include them in their national curriculum for secondary education. In two countries[5] the educational system is more decentralised, leaving schools considerable autonomy. Consequently, the notion of a top-level/national curriculum is applied differently across Europe.

In primary education, more than half of the European educational systems include digital competences as a cross-curricular theme. In 11 educational systems[6], digital competence is addressed as a compulsory separate subject and in 10 it is integrated into other compulsory subjects[7]. Other educational systems combine two

3 French and German-speaking Communities of Belgium, Croatia, Latvia, Luxembourg, Albania, Bosnia-Herzegovina and Turkey.

4 French and German-speaking Communities of Belgium.

5 The Netherlands and UK.

6 Bulgaria, Czechia, Greece, Poland, Portugal, United Kingdom (ENG and WLS), Iceland, Liechtenstein, Montenegro, and North Macedonia.

7 Czechia, Ireland, Spain, France, Italy, Cyprus, Lithuania, Slovenia, Sweden, and Liechtenstein.

approaches, while in two countries all three exist at the same time[8]. Teaching digital skills as a transversal key competence is still dominant at this education level, although many educational systems also already have separate, more specialised subjects. In lower secondary education, the situation is quite similar regarding the cross-curricular and integrated approach. Yet, it is more common that digital competences are taught as a compulsory separate subject. At this educational level, teaching digital competences as a separate, specialised subject, like informatics or computer science, becomes more widespread. At upper secondary level, the number of countries teaching digital competences as a cross-curricular topic decreases slightly. Compared to lower secondary education, fewer countries offer compulsory separate subjects for all students at the upper level, where it is common for students to choose optional subjects. At different educational levels, some countries deliver digital competences through optional separate subjects instead of compulsory ones.

It is important to highlight that there is a difference between teaching broad digital competences as a transversal key competence, and the teaching of a specialised, scientific discipline like informatics or computer science (CECE, 2017). Computing and informatics education in school allows young people to gain a deeper understanding of the digital world. In 2019, half of the European educational systems were reforming their curricula in relation to digital competence, such as: introducing new elements, including computational thinking, or making the subject area more prominent. Despite these changes, the provision of computing and informatics education in Europe remains low. It happens rarely in primary education (only in six cases) but is more common in secondary education. But there is still a high percentage of students at lower and upper secondary level (76% and 79% respectively) who never or almost never undertake coding and programming activities. In recent years, several initiatives addressing computational thinking in both formal and non-formal settings have been organised, both at national and international levels, to complement or supplement the lack of provision in computing and informatics education (European Commission, 2016b). For instance, the EU Code Week[9], promoted in the framework of the 2018 Educational Action Plan, brought coding activities to many schools across Europe, reaching 4.2 million participants in 2019.

In this context, digital competence of teachers and professors is key to offering effective digital education at all levels. Emerging evidence confirms that, during the period of lockdown, many teachers and professors struggled with the situation and lacked the knowledge and experience in how to plan, develop, and deliver teaching through digital means, including identifying the most appropriate platforms and tools (Burke et al., 2020; Giovannella et al., 2020). Prior to the COVID-19 crisis, when asked about their level of preparedness, only 39% of teachers in the EU felt they were well or very well prepared to use digital technologies for teaching, with significant differences across EU countries (European Commission, 2019b). In Europe, three out of four education systems recognise digital competence as an essential element that educators must have for teaching. Yet, this is reflected in recommendations for initial teacher training in only half of European education systems (European Commission, 2019a). The frequency with which teachers have students use digital technologies for projects or class work has risen in almost all Member States since 2013. This is reflected in increased participation rates of teachers in formal education and training including digital skills for teaching.

Moving from primary and secondary education to higher education (i.e., universities), the main challenge is that technological change leads to new demands on people in the labour market and to the need for higher education curricula to be regularly reviewed for their relevance. At present, all Member States face shortages of digital specialists, while training opportunities in digital areas are missing

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in the EU compared to other countries. European institutions of higher education still struggle to respond to the new and changing labour market needs in new technology knowledge fields. In 2018, only 3.8% of EU graduates received a degree in digital technologies (Eurostat, 2020). In comparison with other STEM fields in the same year: engineering, construction and manufacturing make up 15.2% of the total number of graduates; while natural sciences, mathematics, and statistics 6.4%. Furthermore, the situation of currently enrolled students does not show much improvement as shown in the following image, which also clearly demonstrates

the existence of a severe gender gap in digital technologies. Two specific areas where universities have been slow to adapt their curricula and effectively respond to the changing technological landscape and labour market needs are IoT and cybersecurity. In IoT new standards and coding are emerging that are not yet taught in most universities. Cybersecurity curricula are still being left behind in European universities either as self-standing or as cross-departmental, while some estimates suggest that there are EU firms searching for hundreds of thousands of cybersecurity experts without finding them.
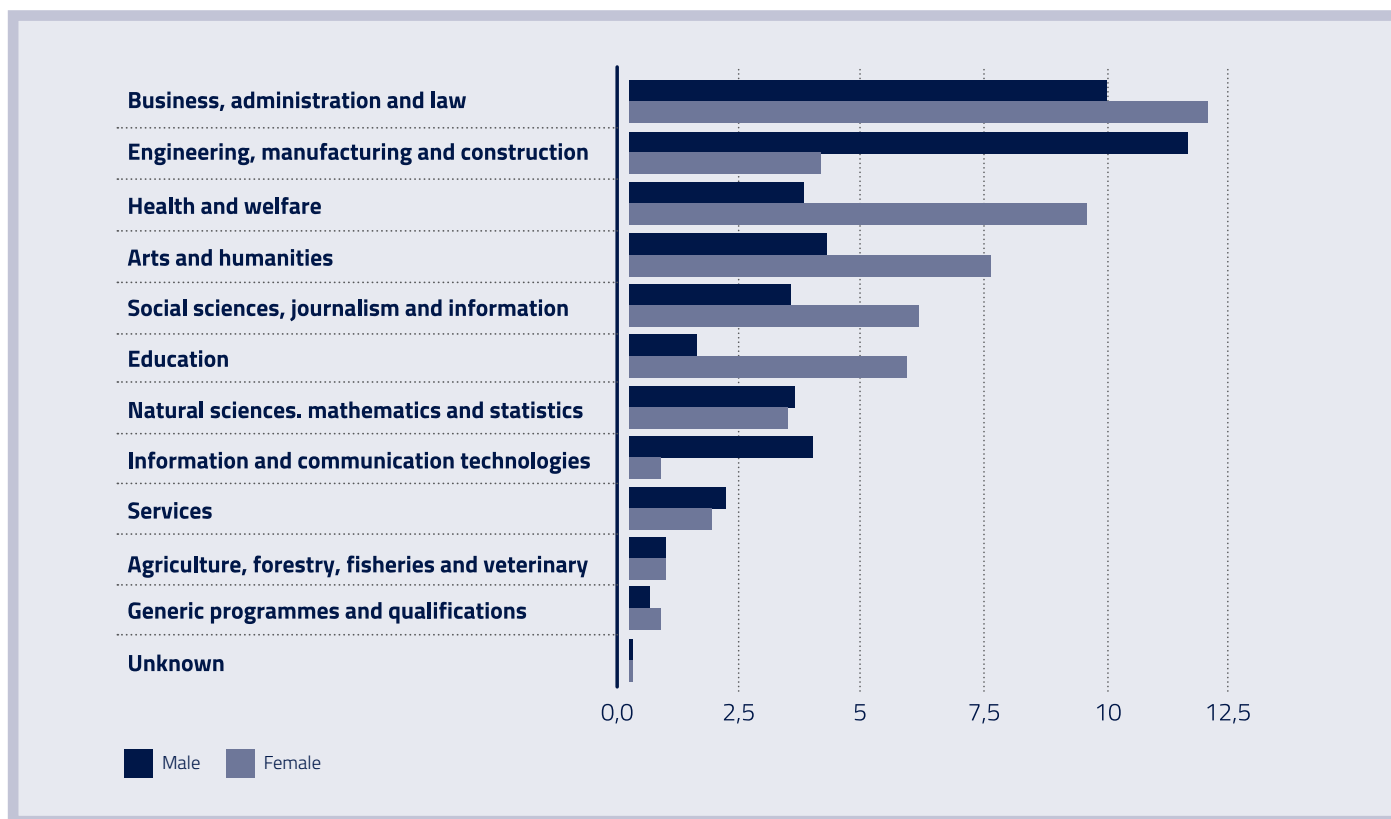
Figure 2 Distribution of enrolled graduate students by field and gender (EU27, 2018, %). Source: Eurostat (2020), online source code: educ_uoe_enrt04

Specialised courses, such as master's courses in emerging domains like Artificial Intelligence are not uniformly available in all Member States and are mostly concentrated in certain regions. The approaches used towards obtaining skills for the digital age can only be effective if they are accompanied by fundamental changes in the process of curriculum development, as well as in the provision of education. As highlighted by the European University Association (2018), higher education in the EU is evolving with a growing demand for short-term learning opportunities, the need for more flexible provisions in degree programmes and a demand from adult learners and professionals looking to re-skill or upskill. The results of the Skills for Industry Strategy 2030 Survey[10] highlighted the need to review the entire educational system and the training offered (European Commission, 2019a).

However, good examples exist that harness the potential of digitalisation. For example: Anglia Ruskin University (UK) has applied the earlier cited DigComp framework for staff development and for embedding digital literacies into its curriculum. Their Digital Literacy Barometer includes competency statements about a spectrum of digital capabilities aligned with DigComp; University of Göttingen developed a basic data literacy course within the Learning to Read Data (Daten Lesen Lernen) project, accessible to bachelor students in every field of study. The latter established a Data Lab as an interface between the different subjects, the regional economy, and society.

The rankings of the top universities providing education in those academic fields relevant to Key Enabling Technologies (KETs) and digital transformation are based on some traditional categorisations, such as life science technologies, engineering, natural sciences, and computer sciences. The same top universities in the world score well in all these areas. These include Oxford, Cambridge, Stanford, Harvard, and MIT. When taking the US and the UK out of the analysis, universities from the EU do not perform well in the top 20 of these rankings. Institutions that do make the rankings are the Karolinska Institute (Sweden) and Wageningen University (The Netherlands) in life-science technologies, Delft University of Technology (The Netherlands) in engineering, the Sorbonne University (France) in natural sciences, and the Technical University of Munich (Germany) in computer sciences. There are some shared features among elite university master's programmes. First, world-class universities all offer distinct programmes in each KET area at all levels (Bachelor's, Master's, Doctorate). Second, KET-relevant programmes in these universities are highly selective, research-oriented, and with high faculty-to-student ratios. Finally, other universities look at what top-tier universities do and adapt their curriculum and services accordingly.

Most of the stakeholders taking part in the Skills for Industry Strategy 2030 Survey agreed that European universities urgently need to adapt their curricula to market needs. Traditional education and training providers often lack sufficient understanding of the high-tech skills required by industry. This leads to a lack of alignment between existing curricula and these skills, ultimately resulting in a growing skills gap. Universities are often anchored to more traditional programmes, which are not updated to the rapidly changing digital sector. Sometimes gaps are signalled from within the private sector. For example, accounting professionals in the US have recently highlighted the need for accounting students to have technology and data analytic skills to be successful in the accounting profession. Several accounting departments have responded by integrating such skills into their curricula (Andiola et al., 2020). However, some skills are difficult to develop in the traditional classroom environments typical for some European universities. Therefore, on the job training is essential to facilitate the transition from theoretical knowledge to practical skills. To achieve this, universities are considering more and more to: involve industrial

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10 The aim of this survey was to include all stakeholders in the development of the final recommendations and give them opportunity to share their final input following the high-level Conference on Skills for Industry Strategy which took place on June 18-19, 2019.

partners, introduce dual-track education for transversal skills, as well as enable continuous education and retraining of the workforce and promoting a wider recognition of certifications. These types of public-private partnerships are better detailed in the following section.

KEY POINTS

- At the primary and secondary level of education, digital competences are taught as a separate well-defined scientific discipline only in few EU Member States. Most of the time digital skills are a cross-curricular theme or are integrated and applied in other subjects.
- Several initiatives addressing computational thinking in both formal and non-formal settings have been organised, both at national and international level, to complement the lack of provision in computing and informatics education (only in six countries at primary educational level).
- Teachers of primary and secondary schools need urgently to be retrained and upskilled. This is a key aspect to offer effective digital education at all levels. However, this is only reflected in recommendations for initial teacher training in half of European education systems.
- On average, European institutions are slow at changing their curricula and when they do, the approach remains very traditional and not adapted to the dynamism of the labour market needs, except for the good practice cases of programmes combining public and private sector.
- There is a very limited and fragmented offer of new specialised Master's programmes in Key Enabling Technologies (KETs) in European universities that, with only a few exceptions, are not at the top position of universities ranking for KETs.
- European universities on average are not very responsive to the need of re-skilling and upskilling the adult population.

TRENDS IN PRIVATE SECTORS OFFERING

The private sector is meant here to include the offering from all non-public institutions: private companies, not for profit organisations and associations.

There are multiple educational opportunities in the private sectors of the EU to tackle both the lower level of basic digital skills among the population and the shortages of digital specialists. While in the first case the actors are mainly associations or competence centres aiming at filling the gaps of the formal educational systems, in the second, the industry is involved in tailoring the curricula of training and educational programs to fill the skills gaps.

Regarding basic digital skills, the most active stakeholder at EU level is the pan-European association All Digital[11] (previously known as Telecentre Europe), which represents member organisations across Europe that work with 25,000 digital competence centres. The association coordinates member organisations representing non-formal education providers to support millions of Europeans with training and advice to succeed in their digital transformation. The focus of their educational activities is on those lacking basic digital skills as a larger underprivileged group, including: the elderly, the unemployed, workers in the industries undergoing automation, adults out of formal education, migrants, and people living in poverty. In addition, All Digital has partnered with other important European networks that share similar missions. For instance, the French Simplon.co[12] network of 53 inclusive digital schools in France and abroad. It provides free and intensive training bootcamps for jobseekers as well as other vulnerable members of the population (women, unemployed, immigrants, refugees) to help them find a job in the tech sector. At the heart of Simplon. co's work there are courses in technical digital skills and hard-to-fill positions for people alienated from work, setting a goal of

11 https://all-digital.org/

12 https://en.simplon.co/

male/female parity as well as for employees in need of reskilling or upskilling. There are also several courses available to children, generally not taught at school, which aim at raising awareness of the digital skills, coding skills and new technologies, but made to be fun for children and young people. These organisations and networks often collaborate with private companies' foundations, as in the case of the Digital SkillShift project[13] that was founded by The JPMorgan Chase Foundation. Also Simplon.co has large digital companies such as Microsoft and Orange among its partners.

Concerning advanced skills for digital specialists, there are several offers on the market. Overall, private-public partnerships are becoming increasingly important to ensure that the courses and training offered are aligned with industry needs. For example, universities cooperating with industry and including industry expert knowledge/input into their curricula could benefit from prioritised public funding to recognise their efforts. There are several examples of such partnerships. For instance, IBM Skills Academy[14] offers trainings to students enrolled in universities. The programme assists universities in filling the gap between academia and business. It improves student learning with hands-on experience using the latest technologies and helping connect them to the job market. The programme has three main components. First, students can access different career offerings and select the one that supports their career goal most effectively (e.g., Big Data Engineer, Cloud application developer, Blockchain developer, Artificial Intelligence analyst). Second, students can learn at their own pace what best suits their individual learning style through the blended learning approach of the programme (i.e., both online and classroom-based environment). Third, students can earn the Open Badge, a digital recognition of skills, which can be shared on social and professional networks and can also be a part of user's digital signature.

13 https://all-digital.org/digital-skillshift-launched/

14 http://www.ibm.com/services/weblectures/meap

15 https://www.developeracademy.unina.it/it/

The tech giants Apple and Amazon have launched similar private-public initiatives of this kind in Europe. The Apple Developer Academy[15] opened in October 2016 in partnership with the University of Federico II in Naples. The one-year course focusses on students learning practical skills and training on how to develop apps. The curriculum was specially designed by Apple's education and software experts with students getting extensive hands-on experience, learning coding and software development skills, as well as gaining knowledge on how to create and run a start-up. Similarly, Amazon launched the AWS Academy, which provides higher education institutions with a free, ready-to-teach cloud computing curriculum that prepares students to pursue industry-recognised certifications and in-demand cloud jobs. By participating in AWS Academy, institutions can help students become proficient and certified in the use of Amazon Web Services (AWS) technology. Amazon started this initiative because the company highlighted that cloud technologies are being rapidly deployed by several organizations, but employees with the necessary cloud skills are missing. AWS Academy offers five courses (Cloud Foundation, Cloud Architecture, Cloud Developing, Cloud Operations and Machine Learning) which are packaged in a modular format that may be delivered to students as synchronous or asynchronous learning in either an educator-led or virtual classroom environment. Curriculum is aligned to and prepares students for AWS Certification.

An important factor in the delivery of initiatives on high-tech skills concerns the collaboration between governments and industrial partners at the local level. This involvement typically can happen in various ways. Technology companies can offer a valuable contribution to high-tech skills development initiatives by providing free access to knowledge assets and technological equipment. Typically, technology companies try to combine this with piloting innovative hardware and software solutions within skills development initiatives, offering students and educators' access to solutions that are close to market release to identify potential user issues before large-scale rollout. This mutually

beneficial mechanism can be seen in the ARM University Program[16] which helps faculty teach the latest technology from ARM and its ecosystem. The Program has developed a suite of Education Kits in a range of core subjects relevant to Electrical, Electronic and Computer Engineering, Computer Science. The licenses for ARM Development Studio are donated to universities free of charge for teaching purposes only. Similarly, the members of the European Schoolnet's Future Classroom Lab[17], since the opening in 2012, have worked closely with a growing number of digital providers to ensure an independently funded and sustainable platform. This collaboration is mutually beneficial as it provides policymakers with a better understanding of the market's needs and gaps, while providing digital companies a lab for piloting new solutions. Furthermore, private-sector involvement can also be driven by the human capital needs of high-tech employers. This is one of the reasons for industrial partners to be involved in the BioBusiness and Innovation Platform of the Copenhagen Business School[18].

There are also private organisations that launched their own independent institutes, which usually provide a certificate at the end of the professional program. Such is the case of NVIDIA Deep Learning Institute (DLI)[19], which offers hands-on training in AI, data science and accelerated computing to solve real-world problems. Developers, data scientists, researchers, and students can get practical experience powered by GPUs in the cloud and earn a certificate of competency to support professional growth. NVIDIA DLI also offers downloadable course materials for university educators and free self-paced, online training to students through DLI Teaching Kits. Educators can also get certified to teach DLI workshops on campus through the University Ambassador Program. Another important case of a private institution is the

Cisco Networking Academy, which was founded in 1997 and it has had over 9 million students in 188 countries, with about 2.2 million in Europe alone. Cisco Networking Academy has advanced its Cisco Certified Network Associate (CCNA) curriculum to prepare job seekers, from anywhere and from any background, with the skills they need for a career in the IT field.

As shown by the previous examples, private organisations are employing unique methods to implement skills development initiatives relevant to high-tech skills. These range from online and classroom curricula to more innovative methods, such as educational laboratories and online platforms that connect supply and demand in areas of the labour market that pertain to high-tech innovation. For instance, Academy Cube[20] provides a platform which allows job seekers to post a digital resume and employers to post job profiles, eventually helping these two to identify potential matches or potential skills gaps. Identified skills gaps can be remedied through online courses available on the Academy Cube platform or through third-party training providers. Another example is Codecool[21], a private organisation aimed at bridging the gap between the accelerating digital transformation and the lack of digital skills. It acts as an intermediary between schools and the workplace, where industry experts act as mentors, who can also offer business insights. Thus, the 1-year course focuses on skills that are needed on the job, while being based on projects and peer learning. The company offers a post-paid model, in which trainees pay the course after 18 months and only if they have been hired full-time, ensuring that the organisation is truly inclusive.

16 https://www.arm.com/resources/education/education-kits

17 http://www.eun.org/it/professional-development/future-classroom-lab

18 https://www.cbs.dk/en/knowledge-society/strategic-areas/biobusiness-and-innovation-platform-bbip/minor-in-bioentrepreneurship

19 https://www.nvidia.com/en-gb/training/

20 www.academy-cube.com

21 https://codecool.com/en/

KEY POINTS

- There are several initiatives from non-profit organisations that mostly target the lower end of very underprivileged groups provided with short crash courses that give them the minimum set of skills to get by in their daily life.

- Private-public partnerships are becoming increasingly important to ensure that the courses and training offered are aligned with industry needs. Universities signing cooperation agreements with industry and including industry expert knowledge/input into their curricula can benefit from prioritised public funding.

- Collaborations between governments and industrial partners at the local level are also increasing in Europe, as private actors benefit from this involvement in different ways. For instance, technology companies can offer a valuable contribution to high-tech skills development initiatives by providing free access to knowledge assets and technological equipment. Furthermore, private-sector involvement can also be driven by the human capital needs of high-tech employers.

- Several private organisations launched their own independent institutes, which normally provide a digital certification at the end of the professional program.

- Specific methods are employed by private organisations to implement skills development initiatives relevant to high-tech skills. These range from online and classroom curricula to more innovative methods, such as educational laboratories and online platforms that connect supply and demand in areas of the labour market that pertain to high-tech innovation.

FROM **GAPS** TO **SCENARIOS**

NEEDS AND GAPS

Based on the Digital Compass targets for 2030 the two key needs on the demand side include: increasing the percentage of European citizens with basic digital skills; responding to the lack of digital specialists, signalled steadily in the changing labour market. In the previous chapter we reviewed what the public and private supply sides have been doing to address these needs. If we consider however, the trends in the past decade and project them into the future it is easy to see that the supply side is not doing enough. A recent Monte Carlo simulation shows that by 2030 Europe will reach neither of the two key targets set in the Digital Compass, namely 80% of the population with basic digital skills and 20 million digital specialists employed (Codagnone et al., 2021, pp. 48-49). Without an exogenous jolt in the form of more investments and/or innovations in the supply side, the current trajectory indicates that by 2030 there will be only 64% of the population with at least basic digital skills (short 16 percentage points from the target) and only 13.3 million employed digital specialists (short 6.7 million from the target). The Digital Compass further sets the goal of convergence between men and women with respect to employment as digital specialists. The cited simulation suggests, instead, that by 2030 if no changes are introduced the gap between men and women will increase rather than be filled. As indicated, Member States have all presented RFF plans with investments exceeding the 20% target of the total budget, and one may expect this bid to contribute to fill these gaps. But reversing the trends is not just a matter of investments. It depends also on changes within institutional settings and governance mechanisms as well as opportunely framed incentives and collaboration schemes for the private offering.

It is obviously beyond the scope and possibility of our analysis to make a one-to-one causal attribution of the unmet needs as to what the specific gaps of the public and private educational offerings in the domain of basic and specialised digital skills are. Sections 2.2 and 2.3 have provided only a helicopter view on the supply side, which nevertheless shows a very diversified and fragmented picture across the different European countries. A causal attribution would require a more granular analysis country by country and a comparative across country perspective. Nonetheless at a speculative level, which is adequate to pave the way for our foresight scenarios, a few gaps in the offering can be identified.

First, there is clear fragmentation across Europe in the approach towards digital competences at primary and secondary level educational system. In a very limited number of cases digital competences are taught as a separate well-defined scientific discipline. Most of the time digital skills are a cross-curricular theme touched upon here and there. Such approaches forego the holistic approach entailed by the DigComp framework. By this we mean that the cognitive and functional aspects of such skills may escape approaches that are specialised in digital skills as such. For instance, the cognitive attitudes of computation and coding, that could shape a favourable mental skill set in young pupils and students are not widely taught. As part of this gap, it is also important to stress that teachers of primary and secondary schools are themselves in urgent need of retraining and upskilling.

Second, on average European institutions at the university educational level for specialised digital skills are slow to change their curricula. When they do, the approach remains very traditional and not adapted to the dynamism of the labour market needs; except for the good practice cases of programmes combining

public and private sector. There is a very limited and fragmented offer of new specialised Master's programmes in Key Enabling Technologies (KETs) in European universities which, with only a few exceptions, are not even on the top positions of universities ranking for KETs. European universities on average are also not very responsive to the need for re-skilling and upskilling of the adult population.

Third, moving out of the public sector there is a lack of supply addressing the middle of the digital skills scale. The NGOs initiatives, in fact, mostly target the lower end of very underprivileged groups provided with short crash courses that give them the minimum set of skills to get by in their daily lives. Yet, between this lower end and the upper end (more privileged groups already skilled), the largest target not addressed neither by the public nor by the private offering is in the middle. These are adults who are part of the lower middle class in need to upskill and reskill both for their daily activity and for their work. Even if not as digital specialists, many employees need to improve their digital skills. Obviously, this large group is not the target of the offer by primary and secondary education, it does not find a lot of courses in the university and is not generally the target of private sector offerings for specialised skills, as the latter are mostly aimed exclusively at the younger segment of the population (18-35 y.o.).

Fourth, the offerings of the tech giants and of other specialised private sector establishments tend to focus more narrowly on their own labour market needs and to be exclusive as attendees need to pay for themselves or be funded. Interesting and promising exceptions are academies where private sector technology players partner with universities and/or with local governments, especially the more inclusive examples where attendees are allowed to pay their fees only after having found a job (i.e., the case of Codecool). These four gaps can help explain why Europe is not on the path toward reaching the 2030 Digital Compass targets. These gaps must be filled if we are to achieve both more digital inclusiveness and more digital labour force productivity. Filling them is not only

a matter of more investments, but it also requires organisational and governance innovation, especially in the public sector. In view of these gaps and what is required to fill them, we propose in the next section scenarios illustrating the rationale chosen for the two dimensions and the values of the extremes of the axes.

THE PROPOSED SCENARIOS

Our choice is to use the supply side to define the scenarios axes, and then discuss the effect on the demand needs and on economy and society as part of the scenario storylines. So, the dimensions used for the axes are the characterisation of the public and private offerings concerning digital-related education and training.
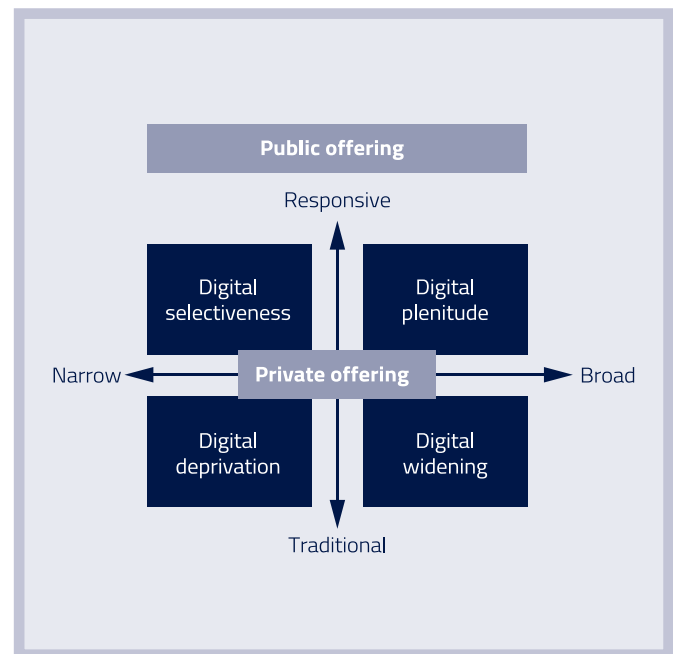

Figure 3 The scenarios. Source: Own elaboration

The rationale for the values at the end of the two axes springs from the analysis of gaps and how to fill them as presented earlier. The public offering varies from responsive to traditional. Responsiveness in the public educational institutions is twofold. It concerns the curricula, but also organisational and governance issues, as well as investments in connectivity for schools. Responsive public sector offerings at primary and secondary level would include digital competences as self-standing subjects with emphasis also on the cognitive and intangible aspects of computational thinking and coding at an early stage, with retraining of teachers, as well as wider access to good Internet connection. At university levels innovative curricula would be better aligned with labour market needs, mainstreamed within and across countries, and new courses offered to the adult population in need of training, reskilling, and upskilling. The organisational and governance responsiveness would take the form of a fully open ecosystem based on close cooperation with technology makers and with industry in general. The opposite value is 'traditional' meaning public offering, which simply means that things will continue as they are today and as we described them in section 2.2. Also, the value of a broad offering in the private and not for profit sectors has a twofold meaning. First, it means that both private companies and not for profit organisations and networks would start also targeting the middle of the digital skills scale, and not just the lower and upper ends. Second, it entails that the offering from tech giants and other private sector makers will broaden its scope to address the needs emerging from the economy and society more generally and almost as a standard, spread the partnerships with public universities and/or with local governments. As for public offering, the opposite extreme 'narrow' is basically the continuation of the status quo as described in section 2.3.

SCENARIO STORYLINES

Digital selectiveness. Public sector offering, through governance reforms and more investments, becomes more innovative, flexible, and dynamically adaptive to the changing technologies and related labour market needs. At primary and secondary level digital competence becomes a separate subject and teachers are retrained and upskilled, while public investments equip all schools with good Internet connection. Universities abandon the traditional and rigid definition of curricula to add more adaptive and dynamic short courses as well as master's in all domains of KETs. This enables (pupils and students of primary and secondary schools, who will later go to university or enter the labour markets) in the middle and short term to better respond to the labour market and industry's changing demands. The full impact of the new responsiveness in the public sector, however, is limited by the fact that the offering of private companies and not for profit organisations remains narrow. This produces a sort of selectivity that limits the widest inclusion possible of all segments of society. Only the lower and upper end of the digital skills scale are targeted, while the needs of the large middle space within remain unaddressed. In addition, the narrow nature of the offerings limits the opportunities for partnerships with public institutions, which in turn prevent the latter to be even for innovative and offer retraining and upskilling services for the adult population. As a result, while the capacity to deliver more specialised skills and the support for industry innovation and productivity increases, no great advances are made in terms of widespread diffusion of basic digital skills, increasing the risks of new forms of digital inequalities.

Digital plenitude. Public sector offering, through governance reforms and more investments, becomes more responsive, flexible, and dynamically adaptive to the changing technologies and related labour market needs. At primary and secondary level digital competence becomes a separate subject and teachers are retrained and upskilled, while public investments equip all schools with good Internet connection. Universities abandon the traditional and rigid definition of curricula to add more adaptive and dynamic short courses and master's in all domains of KETs. This enables in the middle (pupils and students of primary and secondary schools who will later go to university or enter the

labour markets) and short term to better respond to the labour market and industry changing demands. At the same time the broader scope in the offering of private companies and not for profit organisations acts as a multiplier of the gains accruing from a more innovative public offering. Both private companies and not for profit organisations start targeting not only the lower and upper ends of the digital skills scale, but also the needs of the large middle space within this scale. In addition, the opportunities for partnerships with public institutions increase, which in turns help universities, to be more innovative and dynamic and offer new courses for the adult population. As a result, the capacity to deliver more specialised skills and support for industry innovation and productivity increases alongside the widespread diffusion of basic digital skills, greatly reducing the risks of new forms of digital inequalities and exclusion.

Digital widening. Public sector offering, because of difficulties in governance reforms and lack of funds, does not change, continuing in traditional practices of definition of curricula and fairly closed to partnership with private institutions. Their offering remains static and is unresponsive to the labour market and industry changing demands. On the other hand, the wider scope in the offering of private companies and not for profit organisations compensate this. Both private companies and not for profit organisations start targeting not only the lower and upper ends of the digital skills scale, but also the needs of the large middle space within this scale. As a result, while the capacity to deliver more specialised skills and support for industry innovation and productivity is limited, the widespread diffusion of basic digital skills, greatly reduces new forms of digital inequalities and exclusion.

Digital deprivation. Public sector offering, because of difficulties in governance reforms and lack of funds, do not change, continuing in traditional practices of definition of curricula and closed to partnership with private institutions. Their offering remains static and is unresponsive to the labour market and industry changing demands. This is compounded by the fact that the offering of

private companies and not for profit organisations remain narrow. Only the lower and upper end of the digital skills scale are targeted, while the needs of the large middle space within this scale remain unaddressed. Such narrow scope limits the opportunities for partnerships with public institutions, which in turn prevent the latter to be even for innovative and offer retraining and upskilling services for the adult population. As a result, both the capacity to deliver more specialised skills and support for industry innovation and productivity and that of filling the gaps and reducing digital inequalities and exclusion are greatly curtailed. Under this scenario lack of specialised skills and limited diffusion of basic digital skills jeopardise the capacity of the economy and society to move to prosperity and inclusion.

SCENARIOS ASSESSMENT
AND CONCLUSIONS

To assess the four scenarios, we selected five dimensions with their respective score on a 1-7 Likert scale and the resulting radar diagram is represented in the picture below. We first illustrate the five dimensions and the way the score must be interpreted, to then move to explain how each scenario performs.

Under the heading of 'productivity' we also subsumed the innovation and competitive effects, so that this dimension is a general indication of how scenarios perform on economic growth. Public costs must be interpreted broadly as including both the increase in public budget spending and the efforts needed to reform the governance of public institutions which offer educational and training services. Social cohesion measures the extent to which possible new forms of inequalities due to differential capacity to use digital technologies are contained or otherwise decreased. Digital literacy is self-explanatory. By closing the skill gaps, we indicate the extent to which scarcity of the specialised digital skills demanded by industry increases or decreases. A score of 7 is to be interpreted as positive and a score of 1 as negative for all dimensions, except for public costs where the reading is in reverse order. A score of 1 means a lot of public costs and a score of 7, instead, means little or no public costs.

The best scenario of digital plenitude scores at the top of all dimensions, except for public costs. As there are trade-offs, to achieve all other gains, this scenario requires sizeable public budget spending and very challenging and time-consuming efforts at institutional level reforms of the overall governance of public educational systems at all levels (primary, secondary, and university). These efforts, however, would pay off with respect to

all other dimensions. A more dynamic and innovative supply from the public sector would bring to the market the needed specialised digital skills and positively impacts productivity. This multiplying effect of private offerings and the synergy of the latter with the formers will further compound productivity, close the gap effect, and push the diffusion of digital literacy. As a result of gains in all these dimensions, social cohesion will be strengthened both because of more economic growth and equal access to digital skills in society. At the opposite extreme, the digital deprivation scenario scores at the bottom of all dimensions, except for public costs. This scenario imposes little or no pressure on sizeable public budget spending and on the need for institutional reforms. Yet, on the other hand, it misses out on all other dimensions. A static supply from the public sector would not respond to the demand for specialised digital skills (no closing of the gaps) and would negatively impact productivity. The narrow nature of private offerings will greatly reduce the diffusion of digital literacy. As a result, social cohesion will decrease both because of lower economic growth and because of an increase in new digital inequalities and exclusion.

The intermediate scenarios of digital selectiveness and digital widening have opposite mixed scores with respect to the five dimensions. The former comes close to digital plenitude with respect to public costs, impact on productivity and closing the gap, but misses out with respect to digital literacy and social cohesion. The latter comes close to digital plenitude with respect to digital literacy and social cohesion, it has lower impact on public costs, but foregoes the gains on productivity and the capacity of closing the gap with a mismatch between labour market and industry demands and what the supply side produces.
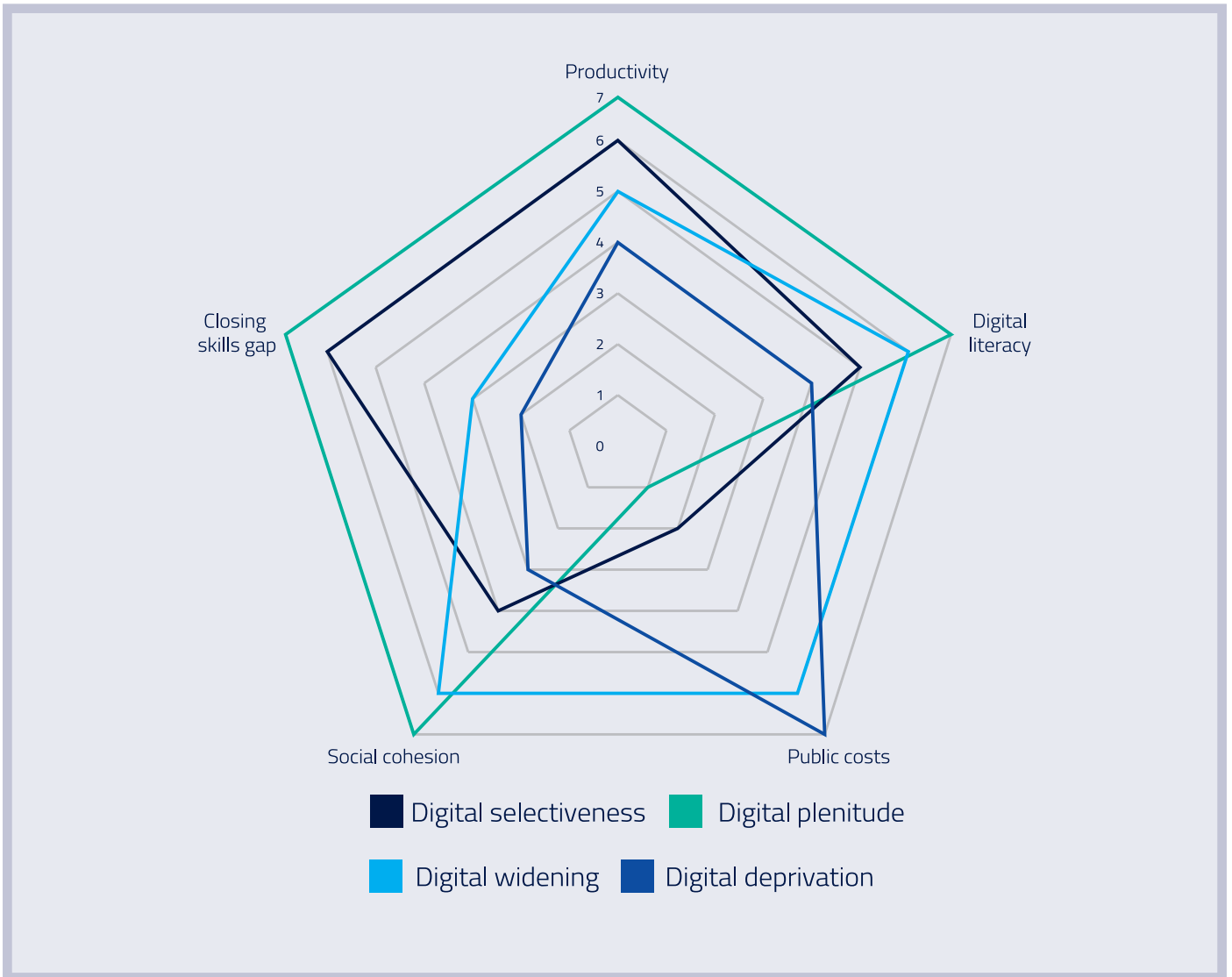
Figure 4 Radar diagram assessment

Considering the previously mentioned RRF investments in the digital transition by the Member States, one may argue that the various ecosystems are already moving along the axes of our scenarios. For instance, this push may lead the public offering to be already up from the traditional lower extreme of the vertical axe. Yet, these are investment plans that have allocated the budget, whereas their implementation is yet to be seen and will take some time before such investments explicate their effect. The budget of investments is, obviously, an important dimension, but how it will be spent and in conjunction with which institutional and governance changes also matters. For these reasons, from the scenarios and their assessment we draw some conclusions that may have policy implications and inform the assessment of the use of the RFF money in the digital transformation pillar. We draw three conclusions:

1. **The entire European public education system, from primary schools up to universities, needs to urgently modernize the largely outdated digital education programs.** The public offering must reform its curricula both at primary and secondary level, and at university level, by making them more responsive to the changing technologies and labour market needs. This requires organisational and governance reforms to open the systems to partnerships with civil society. As well as tangible investments in connectivity and in new training for both teachers and professors.

2. **The scattered private digital education initiatives should move to a complementary, broader, and better coordinated overall offering of digital skills initiatives.** NGOs should broaden their scope in terms of both the topics and the targets of their training, to also reach the middle level in the scale of digital skills. Tech giants and other private players should provide courses that are not just strictly instrumental to their technological ecosystem. In partnership with local governments and/or public institutions, they should offer scholarships or other financial schemes that would increase the pool of participants to their education offering. For this, new partnerships between educational institutions, businesses, NGOs, and governments are needed.

3. **There is a need for better orchestrated pan-European digital skills initiatives, networks and ecosystems to increase overall quality, efficiency, and effectiveness.** To achieve the digital skill targets of the European Digital Compass in a fair, inclusive and sustainable way there is a need for collaboration at the European level given the huge challenges and costs involved. The emerging trends of pan-EU education initiatives like those of the EIT and the European University Networks should be better coordinated and further strengthened and extended to include the private sector. There is an orchestration role for the European Commission to work in close collaboration with EU Member States to establish a fair and inclusive digital skills education system across Europe that involves both public and private education providers.

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