Organisation for Economic Co-operation and Development

EDU/WKP(2020)14

Unclassified **English - Or. English**

14 September 2020

DIRECTORATE FOR EDUCATION AND SKILLS

Digital strategies in education across OECD countries: Exploring education policies on digital technologies

OECD Education Working Papers No 226

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JT03465236

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Abstract

This working paper identifies OECD countries' interests in digital innovation in education by analysing their policy papers on digital education. Many OECD countries have adopted a specific strategy on digital education, or integrated the topic in a generic strategy on digital innovation as such. The ideas that are expressed in the strategies differ greatly; some are work in progress, others contain bold envisions of the future. There is a high awareness among OECD countries of the benefits of digitalisation, and the role of government to support digital innovation in education. This paper covers and documents countries' policy focus before the 2020 coronavirus crisis.

Résumé

Ce document de travail identifie les intérêts des pays de l'OCDE en matière d'innovation numérique dans l'éducation en analysant leurs documents d'orientation sur l'éducation numérique. De nombreux pays de l'OCDE ont adopté une stratégie spécifique sur l'éducation numérique, ou ont intégré le sujet dans une stratégie générique sur l'innovation numérique en tant que telle. Les idées exprimées dans les stratégies sont très différentes ; certaines sont en cours d'implémentation, d'autres contiennent des visions audacieuses de l'avenir. Les pays de l'OCDE sont très conscients des avantages de la numérisation et du rôle du gouvernement dans le soutien de l'innovation numérique dans l'éducation. Ce document couvre et documente les orientations politiques des pays avant la crise des coronavirus de 2020.

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1. Introduction

Society is evolving at a rapid pace. Discussions on self-driving cars, cryptocurrencies and face-recognition surveillance are no longer reserved for science-fiction; they are part of our future history. Innovations are to an ever increasing extent digital, and digital innovations create new opportunities in almost every field of our economies, and hold a promise to improve human welfare and well-being.

Education has not been at the front-line of digitalisation. Even though access to information and communications technology (ICT) infrastructure in schools is widespread in OECD countries (OECD, 2019, p. 179[1]), students will generally encounter new technologies outside the classroom. Recent OECD work shows there has been a moderate level of innovation in educational practices in primary and secondary education, and that this has mainly taken the form of an increased use of technology in classroom and school practices (Vincent-Lancrin et al., 2019, p. 17[2]) However, the coronavirus crisis has shown that the familiarity with digital tools remained limited.

The transition to a digital era concerns education perhaps more than other parts of our societies. Equipping education with the right digital skills and tools is a prerequisite to keep up with ever increasingly demanding digital economies and societies. In this respect, education faces two challenges: reaping the benefits of digital innovations to improve educational practices and policies, and preparing students with the right skills for increasingly automated economies and societies, including, for some of them, the skills to contribute to the further development of digitalisation.

In recent years, many OECD countries have set out strategies to invest in digital education and support educators to transition into the new era. Their attempts prove a great consensus to keep education up to date, and to ensure that students take advantage to live and work in the twenty-first century. While the coronavirus crisis will probably lead to a change in countries' policy priorities regarding the digitalisation of education, this paper aims to document what those priorities were prior to the crisis and thus offers a baseline to assess emerging objectives and priorities.

2. Research and methodology

2.1. Research objective

The objective of this paper is to identify OECD countries' policy interests in the digitalisation of education as of 2020. For that purpose, an analysis has been made of OECD countries' policy papers on this subject in order to distinguish similarities and outstanding differences between them. The analysis was based on two questions. The first question was related to new technologies and their practical use: what are the digital technologies that OECD countries value and support in the field of education? As a result of the outcomes, a second question was formulated: What are the opportunities and challenges OECD countries see?

The paper focuses on primary and secondary education in particular. This does not mean that it has no significance for tertiary education, as technologies can often be applied in more than one education level. It is noted that digital technologies may be particularly relevant in technological education, such as education in science, technology, engineering and mathematics (STEM). This analysis however focuses on the use of digital technologies in regular education. Specific STEM policies have not been taken into account.

This paper was mostly prepared before the worldwide outbreak of Covid-19. Any policy or regulation with regard to online education during the lockdown period has not been taken into account.[1]

2.2. Methodology – use of sources

The paper is based on two types of sources. Primary sources are the documents from OECD countries' governments: most importantly digital education strategies (long-term strategy policy documents that specifically focus on digital education), as well as other online materials, such as informative webpages. Primary sources directly reflect OECD countries' views. Secondary sources are reports from other public organisations. For example, in the case of OECD countries in Europe, reports by European Schoolnet and Eurydice proved valuable.

There are constraints to the availability and use of the sources. In the first place, the information is fragmented. Some primary sources are elaborate, whilst others are more concise. This makes it difficult to compare policies on a one-on-one base. If certain information is lacking in a digital education strategy, it does not necessarily mean that a country has no policy on the subject. It only means that it is not published online, or at least that it is not part of the public strategy documents. As there is no unity between digital education strategies, and websites are not always up to date or properly archived, it is difficult to give a complete picture. Secondary sources are often not available; the differences between them make it difficult to compare.

In the second place, there is no zero measurement: it is only partially known what the 'state of art' is in OECD countries with regard to the use of digital technologies, with most information relating to IT infrastructure and use. The analysis is therefore restricted to challenges and opportunities *as seen and explained by governments of OECD countries*. The feasibility of plans and projects is not part of the analysis. It should be taken into account that the primary sources are often written with a political objective. In many cases, they provide proposals and visions for the future, instead of information on current performances.

In the third place, due to the nature of the subject, sources are quickly outdated. As digital innovations develop rapidly, sources older than a few years have been taken into account cautiously. Most OECD countries however have recently published new digital education strategies.

Despite the constraints, the primary and secondary sources provide a clear view on digital education policies.

2.3. Digital education strategies and strategies on digital innovation

Digital education has become an important strategic topic in virtually all OECD countries. Half of them have published a digital education strategy. In Australia, Belgium and Canada, state governments have taken responsibility for the digital education strategy, sometimes in cooperation with the federal government. In Germany, the Constitution was amended to create a basis for the *DigitalPakt*, an agreement between federal and state governments on digital education.[2]

[1] Specific information on education during and after the Covid-19 pandemic has been collected and published on the OECD Education blog at oecdedutoday.com/coronavirus/ (accessed September 2020).

[2] https://www.bmbf.de/de/wissenswertes-zum-digitalpakt-schule-6496.php (in German). (Accessed May 2020.)

In case OECD countries did not adopt a digital education strategy, information about digital education was often available in a broader national strategy on digital innovation as such. For example, the Estonian digital agenda for 2020 connects an update of the curriculum to the acquisition of ICT skills that are needed in different professions and sectors (Government of the Republic of Estonia, 2018[3]). OECD countries have also published information about digital education on their websites; this information has not been regarded as a strategy in itself, but has been taken into account for the analysis. Finally, some OECD countries have created public digital platforms to support education. A few of these platforms have been analysed for this paper.

There is an important difference between digital education strategies on the one hand and generic strategies on digital innovation on the other. Digital education strategies aim at education and visualise how digital innovation can benefit education. Generic strategies have a different focus, often economic growth and modernisation. If education is part of a generic strategy – not rarely in combination with research and science – the purpose is often the other way around, that is, to visualise how education can benefit digital innovation or the digital economy. STEM education takes an important place in these digital strategies.

3. Digital technologies in education

Most innovations today are at least partly enabled by digital technologies or embodied in data and software (OECD, 2019, p. 13[4]), and digitalisation has been one of the main drivers of innovation in educational practices in the classroom in the past decade. (Vincent-Lancrin et al., 2019[2]) This paper starts with an analysis of the digital technologies that OECD countries value and support in the field of education, in as far as they are part of their digital education strategies.

OECD countries acknowledge the benefits of digitalisation and the role of government to support digital innovation. Digital education strategies cover several opportunities in the field of education. At the same time however, they illustrate that OECD countries tend not to be primarily involved in the development of specific technologies. Instead, they rather focus on societal challenges that originate from the digital transition (see section 4). In as far as digital education strategies mention technologies, it is often with regard to the opportunities for education. Some countries have adopted a specific strategy on artificial intelligence (AI), which often contain a consideration on education and lifelong learning. AI strategies have been taken into account only to the extent where they are relevant for education.

This section provides a typology of the digital technologies and their uses that are referred to in digital education strategies. It should not be seen as an oversight of what is currently happening in OECD countries, but rather as an outcome of what they have explicitly put down about their vision on digital innovation.

3.1. ICT infrastructure

A first striking similarity between digital education strategies is the prominent place of ICT infrastructure: a high-speed connection to the Internet, and the availability of devices (computers, tablets) to use digital services. Even though ICT in itself is anything but new, and most students in OECD countries have access to computers in schools (OECD, 2019, p. 183[1]), advanced ICT creates better opportunities for digital innovation. Accelerating innovation cycles require higher standards for Internet connectivity and digital devices.

Internet connectivity

Investments in ICT infrastructure are often part of digital strategies rather than of digital education strategies, as they generally serve broad purposes. Encouraging the adoption of ICT in specific sectors like education was a top ten priority in OECD countries in 2017, and expected to become even more important in the period until 2022. (OECD, 2017, p. 36[5]) Australia's *National Broad Network* project for example was established in 2009 to design, build and operate Australia's broadband access network. The projects key objective is to ensure all Australians have access to fast broadband at affordable prices (Government of Australia, 2018, p. 31[6]).[3] Students and schools benefit from the investment.

The United Kingdom tied itself to building a world-class digital infrastructure by investing in the 'networks of the future': full fibre and 5G. The digital strategy states that GBP 400 million will be invested in a *Digital Infrastructure Investment Fund*, and that public funding is made available for the roll-out of full fibre broadband networks in partnership with local authorities across the country. Furthermore, a new broadband universal service obligation must ensure that every individual, business and public premise across the country has the right to request an affordable, high speed broadband connection at a sufficient speed for an average family to make full use of the Internet, up to a reasonable cost threshold (Department for Digital, Culture, Media and Sport of the United Kingdom, 2017[7]).[4]

The United States has placed the ICT infrastructure at the heart of its digital education strategy. Affordability remains the primary obstacle for robust connectivity, and network speed and capacity pose significant challenges for schools. A lack of competition for broadband services is particularly problematic in rural areas. The United States strategy requests leaders to take responsibility and ensure ubiquitous access among education stakeholders to connectivity and devices, as well as to support personnel to ensure equipment is well maintained. Leaders should recognise the importance of building capacity for creating and maintaining the technology infrastructure (Department of Education of the United States, 2017, p. 45[8]). The United States also listed key elements for infrastructure plans for schools, which include network management, technical support, maintenance and upgrade of devices and equipment, insurance, licensing, and firewall protection, amongst others (Department of Education of the United States, 2017, p. 81[8]).

Japan has taken fiscal measures to promote investments in ICT infrastructure in schools, according to the document *Utilization of ICT and data in school education*. The Japanese digital education strategy claims that a high-speed and large-capacity network and the availability of computers are essential to work with advanced digital technologies. The strategy also mentions the importance of cloud computing and virtual private networks (Ministry of Education, Culture, Sports, Science and Technology of Japan, 2019[9]).

In-depth information about investments is scarce. Eurydice has provided a brief oversight of ICT infrastructure in Germany, Ireland and Poland. (Eurydice, 2019, p. 90[10]) The federal government of Germany has invested five billion euros under the *DigitalPakt*; the state governments each contribute with a minimum of ten percent of the amount invested by the federal government. The Irish *Digital strategy for schools* has committed 210 million euros (2015-2020); Poland has spent over EUR 372 million for its *Nationwide Education Network.*

[3] See also nbnco.com.au/corporate-information/about-nbn-co. (Accessed May 2020.)

[4] See also gov.uk/government/publications/uk-digital-strategy/1-connectivity-building-world-class-digital-infrastructure-for-the-uk. (Accessed May 2020.)

Digital devices

The second aspect of the ICT infrastructure is the availability of appropriate digital services. Access to computers is part of many digital education strategies, although mobile learning devices like tablets and smartphones are increasingly important. There is no clear line on what kind of devices are best for any kind of education. The United States' strategy states that selecting the appropriate devices depends in large measure on the age of students, their individual learning needs, and the types of learning activities that will be ongoing in the classroom or in after school programmes (Department of Education of the United States, 2017, p. 76[8]).

Several digital education strategies contain considerations about "bring your own device" (BYOD) policies. BYOD means that students bring their own devices and connect them to the Internet (Wi-Fi) at school. There seems to be no systematic yes or no against the use of BYOD, but strategies warn against using BYOD as a primary method for ensuring that students have access to digital education. It can widen gaps between students, as digital devices may not be affordable for every student. The United States mentions an instructional burden for teachers, who have to manage learning activities while supporting multiple platforms and device types. Activities can also be incompatible with certain devices. Finally, there may be privacy and security issues with regard to the use of personal devices, as they might lack required safeguards (Department of Education of the United States, 2017, p. 76[8]).

Occasionally, digital education strategies mention more specific devices. Hungary for example ascertains that a minimum percentage of specialised classrooms within a school should have interactive display devices suitable for 3D display, and that there should be at least one 3D printer per every 500 students in primary and secondary schools. In addition, a programmable robot must be available for every three students in a computer classroom (Government of Hungary, 2016[11]).

As part of the 2015 Digital Education Plan, France deployed a longitudinal assessment of educational digital activities – *ELAINE* – to measure the effects of the distribution of digital equipment on students' skills and on teaching practices and the attitude of teachers towards digital learning.[5] The measurements started in 2018 and 2019; the earliest results are expected in 2021.

3.1.1. Public-private partnerships

Occasionally, OECD countries mention public-private partnerships as part of their strategy for ICT infrastructure. This is for example the case in the Flemish Community of Belgium and in the Netherlands.

According to the European Schoolnet report, the Flemish Community of Belgium has made arrangements for a framework agreement with the private telecom sector and software resellers to provide better conditions for educational institutions (European Schoolnet, 2017[12]). The Netherlands contribute to public-private partnerships with publishers, distributors, and software providers to build a vision of the educational resources chain. This vision must centre on the education sector as a *user*, which should be put first in the partnerships. The Netherlands support *SIVON*, a cooperation between school boards that are jointly committed to achieving a better match between supply and demand on the educational resources market (Ministry of Education, Culture and Science of the Netherlands, 2019, p. 9[13]).

[5] More information can be found on education.gouv.fr/presentation-de-l-etude-elaine-303264. (Accessed June 2020.)

More generally, some digital education strategies acknowledge the importance of the private sector for educational technology, often simply referred to as EdTech. The Flemish *I-LEARN* tender proposal for example challenges EdTech companies to open up their digital applications for education. The proposal states that *I-LEARN* is meant to unite Flemish companies and create a Flemish version of the British Educational Suppliers Association, a trade association for the educations suppliers sector in the United Kingdom which operates on a not-for-profit basis.[6]

The strategy of the United Kingdom claims that a dynamic business sector is crucial for its ambitions. It aims to ensure a choice of high-quality, evaluated products that meet the needs of educators, to harness the new ideas and emerging technologies that have been developed by innovative start-ups, and to help providers with proven products to scale and grow. With regard to organising demand, the United Kingdom has taken several actions, such as recommending buying deals for schools to get cheaper prices, and facilitating a better online marketplace for EdTech (Department for Education of the United Kingdom, 2019, p. 20[14]).

3.2. Advances in existing ICT technologies

Although perhaps not the most futuristic prospect, many innovations are based on advances in existing ICT, such as the Transmission Control Protocol and Internet Protocol (the communication technology which made the Internet possible). (Akgiray, 2019[15]) Initiatives like massive open online courses (MOOC) and digital platforms stem from such advances, or on combinations of advanced ICT and AI.

In this regard, digital learning environments have been put forward by several OECD countries as an opportunity for education. This section deals with the wide range of digital learning environments, as mentioned in the strategies.

3.2.1. *Digital learning environments*

Education systems have been accustomed to digital portals, learning management systems and other digital technologies for the last decades. New technological advances continue to create opportunities for policy makers and educators to integrate digital innovation in the system and learning activities.

Digital learning environments are not a new phenomenon, but their possibilities keep advancing and OECD countries and economies have put interest in the new opportunities they offer. Digital learning environments have been broadly described as 'technical solutions for supporting learning, teaching and studying activities', including combinations of different technical solutions. (Suhonen, 2006[16]) This broad definition justifies the wide variety of functions that have been assigned to digital learning environments by OECD countries, although it underlines as well how difficult it is to accurately describe the matter.

Some OECD countries have chosen to be actively involved by creating digital learning environments at a national level, offering a wide range of services for different stakeholders: management, teachers, students, parents. Services include – amongst others – access to resources, cloud storage, learning analytics, integration of social media, as well as tools for learning, including collaborative learning and community networks, and

[6] 'Project proposal I-LEARN. Personalised digital learning in Flemish education' (Gepersonaliseerd digitaal leren in het Vlaamse onderwijs), i-learn.vlaanderen. (Accessed May 2020.) See besa.org.uk for more information on the British Educational Suppliers Association.

assessment. As the next examples show, data exchange and storage can be an important part of (and reason for) digital learning environments too.

Estonia's digital project *e-Estonia*, a public digital environment that has been running for several years, encompasses education.[7] The website contains four features: (1) the *Estonian Education Information System*, a state database that brings together all the information related to education in Estonia; (2) *eKool* and *Stuudium*, two widely used web tools that provide an easy way for parents, teachers and children to collaborate and organise all the information necessary for teaching and learning; (3) *e-Schoolbag*, a portal that contains learning materials and allows access from a single point; and (4) other e-school solutions, such as *ELIIS*, an online software solution that provides innovative and digital solutions for pre-schools and kindergartens to organise their daily work, *Foxcademy*, a platform with games, 3D models, videos, etc. that allow students to understand subjects in a better way, and *Roboversity*, a set of robotics training programmes to push gifted students to develop their engineering skills further.

Another existing public digital environment, the Danish *User Portal Initiative* (*Brugerportalinitiativ*) provides a public infrastructure and standardisation framework for learning management systems and data exchange across schools in the country. The portal was initiated after an agreement between the Ministry of Education and municipal councils to establish a digital platform that provides a single entry point for all educational data and digital services held and used by schools.[8]

The Luxembourg *Digital4Education* portal leads to several digital learning environments, such as: *eduSphere*, an online teaching and learning platform that enables teachers to deliver modern, multimedia-based lessons; *Bee Creative*, an initiative to allow young people to use digital technologies (digital literacy) and to promote creativity, talents and entrepreneurship in this context; and *MathemaTIC*, a personalised, multilingual math learning environment.[9]

Besides public digital learning environments, which can be offered at different government levels, OECD countries also tend to encourage schools and teachers to use digital learning environment services from private companies. For example, Israel has set up a programme to encourage teachers to implement tools and digital environments for learning and assessment processes, with an emphasis on alternative assessment methods to promote collaborative learning. The programme is meant for digital learning environments that enable students to (1) build personal and collaborative knowledge through online tools and digital information, (2) to use digital communication with other students and teachers in an intelligent way, (3) share information in a variety of textual, visual and auditory media, and (4) have an in-depth dialogue with other students on learning contents. The programme is focused on the intelligent use of digital learning environments by teachers and students (European Schoolnet, 2018, p. 16[17]).

3.2.2. Access to resources

Partly in relation to digital learning environments, several OECD countries have shown interest in (open) access to digital resources, notably digital educational materials. Enabling

[7] e-estonia.com/solutions/education. (Accessed May 2020.)

[8] https://www.kl.dk/nyhed/2014/oktober/nyt-brugerportalinitiativ-til-den-digitale-folkeskole/ (in Danish). (Accessed February 2020.)

[9] portal.education.lu/digital4education/. See also digital-luxembourg.public.lu/initiatives/digital4education for more information in English. (Accessed May 2020).

open access creates two challenges however. First, there needs to be an adequate amount of digital resources. Digitisation of educational content is therefore part of some digital education strategies. Second, access to digital resources may be restricted by security measures and intellectual property. Some digital education strategies therefore contain considerations about open access and licence agreements.

According to the United States strategy, the use of openly licensed educational resources is one of the most effective ways to provide high-quality learning materials at scale. Open licenses should make the use of resources possible without paying any licensing fees or requesting permission. For learning resources, open licenses such as *Creative Commons* could be used, and for software, open licenses such as *GNU General Public License*, or other licenses recognised by the Open Source Initiative or the Free Software Foundation. The United States currently spends USD 8 billion per year purchasing commercial learning resources. Besides cost savings, openly licensed materials could also be more accurate than traditional textbooks, because they can be updated continually as content changes. Finally, the strategy states that openly licensed materials allow teachers to exercise their own creativity and expertise, so they can tailor learning materials to meet the needs of their students (Department of Education of the United States, 2017, p. 77[8]).

Turkey expresses interest to create an ecosystem for the development of digital content and skills. A national archive will link digital and printed materials to each other, and provide teachers with supporting materials. Digital content will also be used to prepare a digital platform to enable customised learning experiences (Ministry of National Education of Turkey, 2019[18]).

The Netherlands have made open-access of educational resources – making them available, usable and relevant – a priority. While a great deal of open-access learning material is being developed in and outside the education sector, this material is often not used to its full effect, according to the Dutch strategy.

3.3. Data management and learning analytics

Digital innovation is data-driven. Even though data has always been around in education, technologies like AI and the Internet of Things (IoT) increase the effectiveness and thus the value of data. Algorithms require vast quantities of data, creating an incentive to maximise data collection. Digitalisation will further increase the collection of data, which will become more frequent and easier. Because data can help teachers, administrators and policy makers to improve education (policies), data are an important part of digital strategies and digital education strategies. At the same time, it is difficult to compare countries' interest in data, as digital education strategies vary widely on this subject. Initiatives may for example relate to student identification and (central) data storage, or to learning analytics for feedback or evaluation purposes.

Improving education systems through better data analysis and foresight is the third priority of the European Union action plan. Big data and learning analytics offer new opportunities to capture, analyse and use data to improve education. While many countries from the European Union swift away from the 'one-size-fits-all' teaching approach to more personalised learning, learning analytics can improve personalised learning, e.g. by identifying at-risk students, and evaluate the impact of different teaching strategies. The European Union underlines that learning analytics are however still in its infancy in Europe. The way forward is – amongst other initiatives – to launch AI and learning analytics pilots in education to make better use of the huge amount of available data and thus help address specific problems and improve implementation and monitoring of education policy (European Commission, 2018[19]).

New South Wales (Australia) has founded the Centre for Education Statistics and Evaluation to provide data analysis, information and evaluation that improve effectiveness, efficiency and accountability, collect essential education data and provide a one-stop shop for information needs, and build capacity across the education sector so that everyone can make better use of data and evidence.[10] In order to make data accessible, the centre also uses other resources, like the *School Finder tool* that puts school location data onto maps.

Turkey plans to integrate data from existing systems within an easily accessible *Educational Data Warehouse*, which will also run a learning analytics platform to evaluate academic data of students together with data about their interests, talents and temperament. The learning analytics tool should lead to a better understanding of learning and teaching processes, and provide effective feedback. Furthermore, Turkey plans to introduce school-level data-based management. Its strategy contains a plan for an online platform by which the ministry and school administrators can monitor school development plans. With regard to evaluation, a qualification-based evaluation system is to be established to identify, monitor, and support the qualifications of children in all courses and levels. An e-portfolio will be prepared to monitor, evaluate, improve, and orient the child from early childhood until the end of upper secondary education (Ministry of National Education of Turkey, 2019, p. 30[18]).

Hungary has put emphasis on the standardisation of administration systems at central and institutional levels. It has proposed that they should be accessible with a single user identification, and that the identification of students and teachers should be based on a common directory service (Government of Hungary, 2016, p. 56[11]).

Japan has included learning analytics in its digital education strategy. It recognises the possibilities of learning analytics to provide useful data about students to teachers, which can be used to improve the discussion between teacher and students. The strategy underlines however that learning analytics should be used appropriately, and that access should be concentrated. There should be an alternative if learning analytics cannot be deployed in a given circumstance. Furthermore, Japan expects that the use of advanced technology and educational big data can lead to reforms for teachers and management, in particular by results processing and attendance and time management (Ministry of Education, Culture, Sports, Science and Technology of Japan, 2019[9]).

3.3.1. Open data

Open data standards are occasionally mentioned in digital education strategies. In many ways, open data can contribute to education in the way open access to digital resources does. The United States strategy mentions open standards as a means to ensure interoperability with other learning networks and thus as a key element for digital infrastructure for schools (Department of Education of the United States, 2017, p. 81[8]).

Québec (Canada) has defined open data as 'raw, non-nominal, royalty-free data produced or collected by a public or private organization and made accessible to the public on the Internet'. The digital education strategy continues that open data reflect the principle of transparency in public administration, facilitate the participation of citizens in developing innovative solutions and fosters economic development. Open data provide relevant information for the general public, analysts, developers, innovators and researchers. To foster the use of open data, Québec supports the organisation of education hackathons, like the *Repenser l'école hackathon* (Ministry of Education and Higher Education of Québec, 2018, p. 41[20]).

[10] data.nsw.gov.au/case-studies/nsw-education-data-hub. (Accessed May 2020.)

Open data standards are often part of generic digital strategies. New South Wales (Australia) for example works with an open data policy. Its objectives are – amongst others – to assist government agencies to release data for use by the community, accelerate the use of data to derive new insights for better public services, and use data to inform the design of policy, programs and procurement.[11]

The European Union too has set out a directive on open data and the re-use of public sector information. A new version of this directive was adopted in 2019, to be implemented by European Union member countries by July 2021. On the basis of the directive, EU countries shall ensure that certain documents shall be re-usable for commercial and non-commercial purposes. The directive applies to documents in the public domain, for example publicly funded research projects and digitised books from libraries.[12]

3.4. Artificial intelligence

AI is likely the most eruptive technology nowadays. It has been described as arguably *the* driving technological force of the first half of the century, transforming virtually every industry. (Holmes, 2019[21]) In the field of education, AI has been the subject of research for more than three decades. Most digital innovations in education are based on AI, or on combinations of AI and other technologies.

Box 3.1. Artificial intelligence (AI)

In 2019 the Expert Group on AI at the OECD defined the AI system as a machine-based system that can, for a given set of human-defined objectives, make predictions, recommendations or decisions influencing real or virtual environments. AI systems are designed to operate with varying levels of autonomy. AI system lifecycle phases consist of: 1) planning and design, data collection and processing, and model building and interpretation; 2) verification and validation; 3) deployment; and 4) operation and monitoring. (OECD, 2019, pp. 23-24[22])

One of the most promising AI techniques is machine learning, which is described as a set of techniques to allow machines to learn in an automated manner through patterns and inferences rather than through explicit instructions from a human. Behind machine learning is a technique referred to as 'neural networks', which is accompanied by growing computational power and the availability of massive datasets, also known as big data. (OECD, 2019, pp. 27-28[22])

In education, AI is embedded in many technological innovations that provide learning analytics, recommendations and diagnosis tools in various ways and for various purposes. In many cases, AI applications are still nascent and used in experimental and local contexts rather than at scale at the system level. In practice, there are however many examples of promising uses that foreshadow how AI might transform education in the next decades, both in the classroom and at the system level, and address different stakeholders: students, teachers, administrators, parents, as well as policy makers.

Over the last years, several OECD countries have adopted strategies on AI. The OECD AI Policy Observatory contains a comprehensive, real-time database of AI policies from

[11] digital.nsw.gov.au/policy/data-information/making-data-open/nsw-open-data-policy. (Accessed February 2020.)

[12] https://ec.europa.eu/digital-single-market/en/open-data. (Accessed May 2020.)

around the world.[13] Many AI strategies contain considerations about (higher) education and skills with regard to digital innovation and the labour market for AI. For example, Finland has introduced *Elements of AI*, an online course to enable citizens with a non-technical background to contribute to technological innovation.[14] Section 4.1 deals with skills in the light of digital innovation.

AI is rarely specifically mentioned in digital education strategies, and if so, it is often in general wordings. France for example mentions that the development of AI will support teachers in their daily practice by helping them with the evaluation and assessment of students, amongst other chores (Ministry of National Education and Ministry of Higher Education of France, 2018, p. 12[23]). The United States puts forward that AI can help students to see patterns in the work of students, and support teachers by using student expression as an instructional resource (Department of Education of the United States, 2017, p. 19[8]). Japan too states that although AI is not able to replace humans, the technology easily attracts children's interest and is interesting to reduce the burden of learning guidance for teachers (Ministry of Education, Culture, Sports, Science and Technology of Japan, 2019[9]).

Even though digital education strategies do not specifically elaborate on the use of AI in education, OECD countries' interest is sometimes expressed when they address specific opportunities for education that are based on AI technology.

3.4.1. *Assessments*

Several OECD countries recognise the promise that digital technologies – AI in particular – hold for assessing students. Ireland for example puts assessment in the title of its strategy, which contains a section on assessment reform. Deploying simulations, digital games, virtual worlds and labs, and e-portfolios enable teachers and students to access learner performance data in context (Department of Education and Skills of Ireland, 2015, p. 24[24]).

Israel has placed special emphasis in its ICT program on alternative assessment methods that promote collaborative learning. Digital environments should contribute to an assessment culture in which teaching, learning and assessment processes are integrated.[15]

Sweden is currently developing digital national tests. The National Agency for Education published a list of technical requirements that schools must have in place to implement the digital national tests by 2020, amongst which a stable internet connection, enough portable or stationary computers or tablets, and headphones.[16]

Assessing students also plays a significant role in the United States strategy. Technology-based assessments enable new activities, such as graphic response, simulations, and performance-based assessments that allow students to construct an original response rather than selecting the right answer from a list. Real-time feedback, increased accessibility (e.g. for students with special needs), adaptation to students' abilities and knowledge, and

[13] To access the observatory: oecd.ai. (Accessed September 2020).

[14] 'Artificial intelligence – Finland's 1% AI education strategy', sciencemediahub.eu/2019/06/26/tekoalyaika-finlands-1-ai-education-strategy/. (Accessed May 2020.)

[15] 'General information about the ICT programme in Israel', sites.education.gov.il/cloud/home/lmida_shitupit/Documents/ICT%20Cloud.pdf. (Accessed May 2020.)

[16] Eurydice national policies platform, eacea.ec.europa.eu/national-policies/eurydice/content/national-reforms-school-education-71_en. (Accessed February 2020.)

embedment with learning processes are important advantages for digital assessment (Department of Education of the United States, 2017, pp. 58-59[8]).

3.5. Blockchain

To date, blockchain has drawn little attention with regard to its application in education. While blockchain might be a relative new technology, and only a handful of member countries have adopted the technology with regard to education, there are a few examples worth elaborating on.

Box 3.2. Blockchain

A blockchain is a decentralised peer-to-peer network of transactions, confirmations and ownership transfers. It consists of 'blocks', which are transactions that are confirmed by computers on the network, using cryptographic algorithms and smart 'contracts'. Chains of such blocks form a transaction log, which can be summarised into a 'ledger'. Records of ownership can be logged into ledgers permanently. Because ledgers are extremely difficult to corrupt, blockchains have a high level of immutability – making them a strong alternative to traditional centralised databases. (Akgiray, 2019, p. 7[15])

In the core, blockchain is a combination of already existing technologies, that together can create networks that secure trust between people or parties who otherwise have no reason to trust one another. A blockchain enables a secure transfer of value and data directly between parties and can thus diminish the role of intermediaries. (OECD, 2018[25])

A key inherent characteristic of the blockchain technology is that transactions are immutable, that is that they are unchanging over time or unable to be changed. This means that once data has been written to a blockchain, it cannot be changed. Any interested party is able to verify that data have not been altered. (Berryhill, Bourgery and Hanson, 2018, pp. 12-13[26])

Blockchain technology in education is in its early stage, and its promises for education are still far from clear. OECD countries have not given much attention to the technology in their digital education strategies, or if they have – like France for example – the attention is restricted to general remarks that blockchain might generate opportunities for education, in particular for credentialing (Ministry of National Education and Ministry of Higher Education of France, 2018, p. 12[23]).

Australia has included higher education (universities) in its blockchain strategy, stating that blockchain offers technological infrastructure on which credentials can be managed and shared, and that the ability to record or reference credentials on a blockchain provides benefits to students, education providers, employers and other service providers, including recruitment agencies in the employment value chain. Blockchain-enabled credentials empower students with ownership over their own credentials, according to the strategy, and create opportunities for students into an overseas market, where the ability of foreign employers to verify credentials might be lower than in the domestic market. On the other hand, Australia recognises challenges with regard to security and privacy concerns, as well as a need to take away scepticism among stakeholders (Department of Industry, Science, Energy and Resources of Australia, 2020[27]).

As part of the action plan for digital education, the European Union is working on the integration of digital credentials in the Europass platform (European Commission,

2018[19]).[17] The action plan calls for a common technical approach for issuing digitally-signed qualifications to ensure that member states can understand and correctly interpret each other's certificates. The approach is based on open standards and blockchain, and integrated into the existing Europass platform, where digitally-singed qualifications can be stored and shared.

4. Challenges

An important part of digital education strategies deals with societal challenges created by the digital transition. Some challenges will sound familiar: questions about accountability, trust, privacy and security are asked with regard to digitalisation in all fields.

This section deals with two societal challenges that are more specific to education: digital literacy and competences, and digital divides. Finally, it comprises a short paragraph on privacy and security in relation to personal data of students.

4.1. Digital literacy and competences

Education must prepare students with the right skills for the future. This challenge is at the core of virtually all OECD countries' education policies, and comprises two aspects. First, teachers need sufficient training to deploy and teach about digital technologies. Second, countries need a standard for digital skills and literacy for students.

4.1.1. Teacher competences

Despite or perhaps thanks to new digital possibilities, teachers will likely play a central role in the future of education. Luckin and Holmes even predict that AI will serve as a 'catalyst' for the transformation of the role of the teacher. They argue that AI creates freedom from routine and time-consuming tasks, allowing teachers to devote their energy to more creative and human acts 'that provide the ingenuity and empathy needed to take learning to the next level'. (Luckin, 2016, p. 31[28])

While digital technologies should ideally be designed to facilitate teachers, their potential cannot be reached if teachers do not have the right skills to deploy them. There is a continuous risk that investments in digital technologies have no return or even prove ineffective for education, if the technologies are not (proficiently) used in class.

OECD countries have put down different measures to tackle this challenge. Their main challenges are to create more clarity on professional competences on the one hand and to support professional development on the other. OECD countries have expressed interest in reference frameworks for teacher competences, and in teacher training and access to relevant resources. The Québec (Canada) strategy for example refers to both challenges. It has laid down the development of digital competences of teachers, non-teaching professionals and support staff as an objective, containing two measures (Ministry of Education and Higher Education of Québec, 2018[20]):

- Develop a new competency framework for the teaching profession to foster the integration of digital technologies into the educational practices of future teachers.
- Foster the continuing education of teachers, non-teaching professionals and support staff in digital pedagogy.

[17] See also 'Implementing the new Europass Project management plan' on ec.europa.eu. (Accessed May 2020.)

Amongst other countries, Spain has built on the work of the European Commission to publish a common framework for teaching, which contains a standardized proposal for competencies, divided in five areas: information and data literacy, communication and collaboration, digital content creation, safety, and problem solving. (European Commission, 2013[29]) A national institute for educational technologies and teacher training further provides face-to-face (e.g. summer courses, congresses) and online training opportunities for teachers (European Schoolnet, 2018[30]).

In addition to its objective and measures, the Québec strategy mentions two best practices with regard to teacher training. The first is a network of education consultants that offer a platform on which they share their expertise in short online training sessions, free of charge. The platform is intended for teachers and principals, amongst others. The second is *CADRE21*, a centre that aims to develop a culture of professional development among teachers. The centre has a physical location, but the focus is on online access to resources, blogs and customised training, including ICT skills. The training sessions are certified by digital badges.

The United Kingdom has launched online training courses for teachers and leaders in education in partnership with the Chartered College of Teaching. The courses strive to improve the use of technology in teaching, alongside other training opportunities offered by industry. Access is freely available online for all educators (Department for Education of the United Kingdom, 2019[14]).

4.1.2. Digital skills and literacy for students

While ensuring that teachers are digitally competent and equipped is one concern for OECD countries, digital literacy for students is another. Many digital education strategies contain a consideration about the importance to prepare students for a digital age, as well as adapting the curriculum for that purpose.

Digital innovation has created a major challenge for education to prepare students for increasingly automated economies and societies. The *OECD Employment Outlook 2019* estimates that 14% of existing jobs could disappear as a result of automation in the next fifteen to twenty years, and another 32% is likely to change radically as individual tasks are automated. (OECD, 2019, p. 15[31]) This prospect has tremendous effects on the set of skills that people need to make a living in the future, and requires a critical eye on education rather than esthetical adjustments.

AI for example, seems – at this point – to best humans when it comes to repetitive and predictive tasks, tasks that hinge on computational power, classifying huge amounts of data, and making decisions based on concrete rules. People need skills for cases where they trump the performance of machines, for example for making products and results usable for humans and communicating about them, and making decisions about abstract values. (Holmes, 2019, pp. 24-25[21])

There is an ongoing debate on what 'digital skills' exactly are, and what other skills are relevant for students. In an earlier OECD publication, Graaf Hooft elaborates on the work of Helsper and others, who classify 'digital skills' in four broad categories: operational skills, information-navigation skills, social skills, and creative skills. (Hooft Graafland, 2018, pp. 29-30[32]) The first two categories relate to technical and cognitive skills to use a computer and the Internet, e.g. to search, find and understand online information; the last two categories relate to the ability to communicate and interact online, build digital social capital, and create and share quality content online.

Other skills are relevant in this context as well. Complex skills that are not easily automated are becoming increasingly important. Recent studies lay an emphasis on higher cognitive

skills. The World Economic Forum has indicated that skill demand in 2022 will focus on ten different skills, amongst which analytical thinking, active learning and creativity. (World Economic Forum, 2018, p. 12[33]) Creativity and critical thinking do not only meet new labour market demands, but also contribute to human well-being and the good functioning of democratic societies. (Vincent-Lancrin et al., 2019[34]) Finally, the *Skills Outlook 2019* shows that having higher cognitive skills – literacy, numeracy or problem-solving skills in technology-rich environments, or a mix of these – significantly augments the probability that people will move from using the Internet for information and communication to a diversified and complex use, taking other determinants into account. (OECD, 2019, p. 137[1]) (Elliott, 2017[35])

Digital education strategies show there is a shared concern that students need adequate skills for the digital era. Most OECD countries have placed 'digital literacy' on their agenda. The emphasis on digital literacy raises the question what kind of skills are intended. A distinction can be made between generic skills to live and work in a digital age on the one hand and specific skills to apply technologies on the other. An example from Slovenia illustrates that digital literacy may refer to both. After stating that digital literacy is a precondition for inclusion and participation in the digital society, the government continues: "Only digitally literate or e-competent citizens can fully communicate digitally, use modern ICT, develop new skills in different life circumstances, be innovative and creative in the use of ICT, while in-depth understanding of ICT allow them to modify and create new technologies, solutions and ideas of use." (Government of the Republic of Slovenia, 2016, p. 40[36]) This perspective comprises both specific skills to apply ICT and generic skills like innovation and creativity.

Germany addresses a comprehensive understanding of digital literacy, including digital competence as a basic understanding of digital systems, algorithms and coding. Moreover, digital literacy should be a conceptual part of education according to the digital education strategies. Measures taken by the government include an initiative to support basic digital education and the use of digital media in vocational education ('*Vocational training 4.0*') (Federal Ministry of Education and Research of Germany, 2019[37]).

Ensuring digital literacy and inclusion for full citizenship is one of three major challenges for Portugal. According to the digital education strategy, digital literacy – that is 'the ability to access digital media and ICTs, understand and critically assess contents, and communicate effectively' – is part of digital competences, which further include the production of new knowledge through research (processing information, communicating, interacting with and producing digital content). Finally, designing new solutions for different types of problems, the integration of interdisciplinary knowledge and data analysis, intensive use of AI, the use of advanced instrumentation and communication networks and mobile systems, and the development and programming of cyber-physical systems are also linked to digital competences (Government of the Republic of Portugal, 2017, p. 4[38]).

Developing relevant digital competences and skills for the digital transformation is one of the priorities for action for the European Commission. Digital competence is part of a broader agenda to set out competences for lifelong learning, which all citizens should have. According to the Commission, digital competence means the confident and critical use of digital technology; it covers the knowledge, skills and attitudes that all citizens need in a rapidly evolving digital society. Specifically, the Commission also aims to bring coding classes to all schools in Europe, including by increasing schools' participation in EU Code Week (European Commission, 2018[19]).

In summary, teaching students the right skills for the digital society is one of the main challenges mentioned in digital education strategies. There is no uniform standard on what

these skills are or should be. Distinctions could be made between digital skills that are meant for a basic understanding and use of digital technologies, and more 'in-depth' digital skills, meant for a deeper understanding of digital technologies. Some OECD countries have adopted skills in their generic digital strategies. In those cases, education or training are often addressed as means to serve the digital agenda.

4.2. Equity and inclusion (digital divides)

Inclusion is an important topic in digital education strategies. Digital technologies comprise both a promise and a challenge for inclusive education. While recognising the opportunities created by digitalisation, for example with regard to personalised learning, many member countries focus on the imminent risks brought forth by digital technologies.

The digital transition emphasises the importance of digital and other relevant skills, and access to digital technologies. This creates a new risk of inequalities between people who have access to the right education or training and to digital technologies (the haves), and those who have not (the have-nots). Such inequalities – often referred to as the 'digital divide' – can in its turn create new forms of exclusion.

Discussions about the digital divide date back to the expansion of the fixed-line telephone network. (Hilbert, 2015[39]) Digitalisation, notably the further development of AI, enhances the risk of suffering new economic, social and technological divides. This is true on a global level (UNESCO, 2019[40]), but digital divides play a role within national education systems and schools just as well. Digital education strategies address the imminent risk of new digital divides at several levels.

Hungary has announced campaigns to involve groups which are hard to reach. Special services like digital learning workshops, that have been made available at a local level, were designed with attention to the learning needs of for example lower-educated people with weak basic competences (Government of Hungary, 2016, p. 121[11]). The idea to reach out to individuals or groups that are harder to reach, is also present in the policies of Japan and Mexico. In Japan, distance learning is seen as an opportunity for learning exchanges with overseas schools and for joint classes, e.g. to solve problems at small schools (Ministry of Education, Culture, Sports, Science and Technology of Japan, 2019[9]). Mexico has founded an online university for distance learning, Universidad Abierta y a Distancia de México. This non-profit and tuition-free initiative aims at providing online courses that can be followed from home, in particular for regions and groups that do not have access to schools (Government of Mexico, 2017[41]).

Canada has explicitly placed its investments in the Digital Literacy Exchange programme in the light of existing inequalities. The programme (2018-2022) is part of the country's Innovation and Skills Plan and aims to facilitate and encourage the participation of underrepresented groups in the digital economy. According to the programme website, digital skills are increasingly important for Canadians of every age, background, education level and employment status. There are still groups however "who are newly involved with, or haven't fully discovered the benefits of being online. It is important to support these groups to ensure no one is left behind in the digital economy." (Innovation, Science and Economic Development Department of Canada, 2018[42])

The Portuguese strategy emphasises the danger of a digital divide for people who have already left formal education and are not exposed to vocational training. To ensure a level of fairness and social cohesion that will lead to balanced and sustainable development, it is essential to raise awareness about the importance of digital competences. The strategy links the digital divide to measures with regard to skill training and ICT infrastructure. The strategy also underlines that it is critical to strengthen gender equality in terms of access to

and development of digital competences (Government of the Republic of Portugal, 2017[38]).

Outside the discourse of regular education, there are also concerns about the digital divide between boys and girls (the 'gender gap') with regard to STEM education. The European Union wants to support measures to further decrease the gender gap in the technology sector by promoting digital skills among girls and mobilise stakeholders – e.g. companies – to equip girls with digital skills (European Commission, 2018[19]).

Finally, the United States strategy warns that closing the digital divide alone will not transform learning: the digital *use* divide too should be closed by ensuring that all students understand how to use technology as a tool to engage in creative, productive, lifelong learning rather than simply consuming passive content (Department of Education of the United States, 2017, p. 21[8]). According to the strategy, the digital use divide continues to exist between students who are using technology in active and creative ways to support their learning, and students who predominantly use technology for passive content consumption. The strategy states that many schools still do not have access to or are not yet using technology in ways that can improve learning on a daily basis. This underscores the need to accelerate and scale up adoption of effective approaches and technologies. The strategy also advises that schools and districts that are deciding how to incorporate educational technology, should actively involve and engage families during early development and implementation of their digital transformation. Few schools however have adopted approaches for using technology to support informal learning experiences aligned with formal learning goals. At the same time, supporting students in using technology for out-of-school learning experiences is often a missed opportunity, according to the strategy. Learning experiences enabled by technology should be accessible for all students, including those with special needs. Supports to make learning accessible should be built into learning software and hardware by default (Department of Education of the United States, 2017, pp. 7-8[8]).

4.2.1. Minorities

Digital divides pop up at different levels, and inclusion is commonly seen by member countries as one of their major challenges.

A handful of member countries further specifies this challenge with regard to minorities. *Australia's Tech Future* emphasises the differences for indigenous people, whose households are 75% more likely not to have an internet connection. Indigenous Australians face additional barriers around skills, affordability and access to culturally appropriate technology. One of the problems is that many indigenous Australians only access the internet through mobile phones, which means they have lower levels of digital inclusion, which could exacerbate other forms of social exclusion, such as unemployment, education and poverty (Government of Australia, 2018, p. 18[6]).

Québec (Canada) has adopted an approach to take into account the cultural and sociological characteristics of First Nations and Inuit, and has asked students from these groups for recommendations to meet their digital needs (Ministry of Education and Higher Education of Québec, 2018[20]). The Ministry of Education from New Zealand provides guidance and online resources to support Māori language learning (Education Review Office of New Zealand, 2018[43]).

In summary, minorities are a specific group, or groups, that face the challenge of a digital divide with the majority group. In order to close this gap, countries with large groups of minorities have specifically addressed this challenge in their digital education challenge.

Distance learning is mentioned as a possible solution for individuals or groups without sufficient access to schools.

4.3. Privacy and security

In general, concerns around privacy and security of data are part of countries' digital strategies, and often part of their digital education strategies as well. There are different ways to address these issues. Strategies can for example focus on the importance to build secure ICT infrastructure facilities. The digital strategy of Estonia designates security-by-design and privacy-by-design as principles for the development of digital services and IT. Cyber security is an important part of the digital agenda; the strategy states that cyber security capacities will be strengthened and the readiness of the state and private enterprises to cope with cyber incidents will be increased (Government of the Republic of Estonia, 2018[3]).

Implementing measure for better information security and privacy in basic education are part of the action plan for the government of Norway (Ministry of Education of Norway, 2017[44]). A secure ICT infrastructure is an important part of the digital education strategy: ICT systems in the education sector should be designed and secured to protect students from adverse events, such as security breaches or hacking. Stored information must be protected in a way that only those who are allowed to see personal data have access to it.

The United Kingdom strategy also focuses on the importance to build secure technology, but also highlights the importance to raise awareness. The strategy warns that public services can be vulnerable. Securing digital safety is therefore an important part of the digital education strategy. The United Kingdom has published a data protection toolkit to guide schools through key data protection activity. The National Cyber Security Centre provides advice and support for schools and higher education institutions as well. Furthermore, the strategy states that EdTech suppliers should adhere to minimum standards for cyber essentials, developed by the National Cyber Security Centre (Department for Education of the United Kingdom, 2019, pp. 23-24[14]).

The Swiss strategy finally encourages the importance of data protection and security in digital education, as personal data are increasingly important to gain access to online services for example. While some online services are provided free of charge by private providers for the education sector, the further use of data and their storage location usually remains non-transparent. This poses data protection problems. According to the strategy, everyone has a right to know where their data is stored and how their data are used. At the same time, data security should be an important topic in education. Children must be aware of the risks associated with the use and publication of personal data (Department of Economics, Education and Research of Switzerland, 2017, p. 38[45]).

5. Conclusion

The digital transition will have great impact on how and what students learn. OECD countries acknowledge the importance of digital innovation and the role of government to support digitalisation in education. Half of OECD countries have adopted a specific policy strategy on digital education, in which they express their political view on the opportunities that digital innovation may bring to improve education, and on the challenges it may carry. Other countries have often made references to education as part of a generic strategy on digital innovation. In more generic strategies, digitalisation is often seen as a method to pursue other goals, notably economic growth. Even though it is difficult to compare strategies on a one-on-one base, there are some striking similarities between them.

It is important to note that the strategies do not reflect the state of the art of policy implementation within countries. Most of those strategies have no budget nor implementation plan. The ideas they put forward may vary from work in progress to bold envisions. The shutdown of schools after the Covid-19 pandemic has shown that many countries still have a lot of work to do to integrate digital technologies into their education system. However, those strategies present countries' views about the priorities, concerns and opportunities of digitalisation in education.

Digital education strategies rarely go into detail on specific technologies. Instead, they rather focus on the functions of technology, which can be based on advances in existing technologies, on AI applications, or on combinations of technologies. For example, many strategies mention the opportunities created by digital learning environments: digital platforms or portals of all kinds help schools, teachers, students and other stakeholders with their educational processes. They may focus on assessments, digital resources or learning activities as examples. As data can be used to improve education and education policies, learning analytics and data management are often part of countries' strategies too. Digital education strategies focus mainly on the societal challenges that erupt from the digital transition. This paper was restricted to the challenges that are specifically important for education. Skills and competencies take the most prominent place: OECD countries are committed to the education of students for the 21st century and accordingly to the training of teachers. At the same time, several OECD countries address the importance to prevent digital divides and ensure that every child can take advantage of digital education. Another challenge that is mentioned in several digital education strategies, is the importance of data protection (privacy and security).

Finally, a major issue for almost all OECD countries is the ICT infrastructure: the availability of digital devices (computers, tablets) and Internet connectivity. It turns out that digital education strategies have an eye for the basics of digital education. Investments of all kind and additional help for schools take a prominent place in strategies.

The health crisis related to the coronavirus showed that those issues remain relevant in most OECD countries. Updating those strategies and accelerating their implementation will be a major challenge in the coming years.

Box 5.1. Oversight of digital education strategies

Australia 2018

Australia's tech future. Delivering a strong, safe and inclusive digital economy (Australian Government 2018), industry.gov.au

Australia (New South Wales) 2019

Education for a changing world. Policy reform and innovation strategy (New South Wales Government 2019), education.nsw.gov.au

Australia 2020

The national blockchain roadmap. Progressing towards a blockchain-empowered future (Department of Industry, Science, Energy and Resources 2020), industry.gov.au

Austria 2017

Digital roadmap Austria (Bundeskanzleramt 2017), digitalroadmap.gv.at

Austria 2018

Masterplan Digitalisierung (Masterplan digitisation) (Bundesministerium für Bildung, Wissenschaft und Forschung 2018), bmbwf.gv.at

Belgium (Flanders) 2019A

Vlaams beleidsplan artificiële intelligentie (Flemish AI policy plan) (Vlaamse Regering 2019), ewi-vlaanderen.be

Belgium (Flanders) 2019B

Vlaams beleidsplan cybersecurity (Flemish cybersecurity policy plan) (Vlaamse Regering 2019), ewi-vlaanderen.be

Belgium (Wallonia) (Digital Agency) 2018

Baromètre digital Wallonia. Éducation et numérique 2018 (Wallonia digital barometer. Digital education) (Agence du Numérique 2018), digitalwallonia.be/education2018

Canada (Alberta) 2013

Learning and technology policy framework (Alberta Government 2013), education.alberta.ca

Canada (Québec) 2018

Digital action plan for education and higher education (Ministère de l'Éducation et de l'Enseignement supérieur Québec 2018), education.gouv.qc.ca

Denmark 2018

Strategy for Denmark's digital growth (Ministry of Industry, Business and Financial Affairs 2018), eng.em.dk

Estonia 2018

Digital agenda 2020 for Estonia (Government of the Republic of Estonia 2018), mkm.ee

European Union 2018

Digital education action plan (European Commission 2018), eur-lex.europa.eu

France 2018

Digital in the service of the school of trust (Le numérique au service de l'école de la confiance) (Ministère de l'Éducation Nationale and Ministère de l'Enseignement Supérieur, de la Recherche et de l'Innovation 2018), education.gouv.fr

France 2018B

For a meaningful artificial intelligence. Towards a French and European strategy (Villani Report 2018), aiforhumanity.fr

Germany 2019

Digital future. Learning. Researching. Knowing (Digitale Zukunft: Lernen. Forschen. Wissen. Die Digitalstrategie des BMBF) (Bundesministerium für Bildung und Forschung 2019), bildung-forschung.digital

Greece 2019

Digital skills for digital Greece. Action plan 2019 for the promotion of innovation and digital skills (Ministry of Administrative Reconstruction 2019), nationalcoalition.gov.gr

Hungary 2016

Digital education strategy of Hungary (Government of Hungary 2016), kormany.hu

Iceland 2019

Icelandic society 2035-2040. Economic, environmental, regional, and demographic developments (Government of Iceland 2019), stjornarradid.is

Ireland 2015

Digital strategy for schools 2015-2020. Enhancing teaching, learning and assessment (Department of Education and Skills 2015), education.ie

Israel 2017

The digital Israel national initiative. The national digital program of the government of Israel (Ministry for Social Equality 2017), gov.il

Italy 2015

National plan for digital education (Piano nazionale scuola digitale) (Ministero dell'Istruzione, dell Università e della Ricerca 2015), istruzione.it

Japan 2019

Promoting measures to utilize cutting-edge technology to support learning in a new era (Ministry of Education, Culture, Sports, Science and Technology 2019), mext.go.jp

Korea 2016

Mid- to long-term master plan in preparation for the intelligent information society. Managing the fourth industrial revolution (Government of the Republic of Korea, English.msit.go.kr

Netherlands 2019

Digitization agenda. Primary and secondary education (Ministerie van Onderwijs, Cultuur en Wetenschap 2019), rijksoverheid.nl

New Zealand 2018

Leading innovative learning in New Zealand schools (Education Review Office 2018), ero.govt.nz

Norway 2017A

Digitalisation strategy for basic education 2017-2021 (Digitaliseringstrategi for grunnopplæringen 2017-2021) (Kunnskapsdepartementet 2017), regjeringen.no

Norway 2017B

Digitalisation strategy for the higher education sector 2017-2021 (Kunnskapsdepartementet 2017), regjeringen.no

Poland (Working Committee) 2016

The digitalisation of Polish education. Visions and proposals (Working Committee 2016), centrumcyfrowe.pl

Portugal 2017

Portugal INCoDe.2030. National digital competences initiative e.2030 (República Portuguesa 2017), incode2030.gov.pt

Slovenia 2016

Digital Slovenia 2020. Development strategy for the information society until 2020 (Republic of Slovenia 2016), gov.si

Switzerland 2017

Digitization challenges for education and research in Switzerland (*Herausforderungen der Digitalisierung für Bildung und Forschung in der Schweiz*) (Departement für Wirtschaft, Bildung und Forschung WBF 2017), sbfi.admin.ch

Turkey 2019

Turkey's education vision 2023 (Ministry of National Education 2019), 2023vizyonu.meb.gov.tr

United Kingdom 2017

UK digital strategy 2017 (Department for Digital, Culture, Media and Sport 2017), gov.uk

United Kingdom 2019

Realising the potential of technology in education: A strategy for education providers and the technology industry (Department for Education 2019), publishing.service.gov.uk

United States 2017

Reimagining the role of technology in education. 2017 National education technology plan update (US Department of Education 2017), tech.ed.gov

References

Akgiray, V. (2019), "The Potential for Blockchain Technology in Corporate Governance", *OECD Corporate Governance Working Papers*, No. 21, OECD Publishing, Paris, https://dx.doi.org/10.1787/ef4eba4c-en. [15]

Berryhill, J., T. Bourgery and A. Hanson (2018), "Blockchains Unchained: Blockchain Technology and its Use in the Public Sector", *OECD Working Papers on Public Governance*, No. 28, OECD Publishing, Paris, https://dx.doi.org/10.1787/3c32c429-en. [26]

Department for Digital, Culture, Media and Sport of the United Kingdom (2017), *UK digital strategy 2017*, https://www.gov.uk/government/publications/uk-digital-strategy/uk-digital-strategy (accessed on 1 May 2020). [7]

Department for Education of the United Kingdom (2019), *Realising the potential of technology in education: a strategy for education providers and the technology industry*, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/791931/DfE-Education_Technology_Strategy.pdf (accessed on 1 May 2020). [14]

Department of Economics, Education and Research of Switzerland (2017), *Digitisation challenges for education and research in Switzerland*, https://www.sbfi.admin.ch/sbfi/de/home/bfi-politik/bfi-2021-2024/transversale-themen/digitalisierung-bfi.html (accessed on 1 May 2020). [45]

Department of Education and Skills of Ireland (2015), *Digital strategy for schools 2015-2020. Enhancing teaching, learning and assessment*, https://www.education.ie/en/Publications/Policy-Reports/Digital-Strategy-for-Schools-2015-2020.pdf (accessed on 1 May 2020). [24]

Department of Education of the United States (2017), *Reimagining the role of technology in education. 2017 National education technology plan update*, https://tech.ed.gov/files/2017/01/NETP17.pdf (accessed on 1 May 2020). [8]

Department of Industry, Science, Energy and Resources of Australia (2020), *The national blockchain roadmap. Progressing towards a blockchain-empowered future*, https://www.industry.gov.au/sites/default/files/2020-02/national-blockchain-roadmap.pdf (accessed on 1 May 2020). [27]

Education Review Office of New Zealand (2018), *Leading innovating learning in New Zealand schools*, https://www.ero.govt.nz/assets/Uploads/Leading-Innovative-Learning-in-Schools-2018.pdf (accessed on 1 May 2020). [43]

Elliott, S. (2017), *Computers and the Future of Skill Demand*, Educational Research and Innovation, OECD Publishing, Paris, https://dx.doi.org/10.1787/9789264284395-en. [35]

European Commission (2018), *Digital education action plan*, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2018:22:FIN (accessed on May 2020). [19]

European Commission (2013), *Supporting teacher competence development for better learning outcomes*, https://ec.europa.eu/assets/eac/education/experts-groups/2011-2013/teacher/teachercomp_en.pdf (accessed on 1 May 2020). [29]

European Schoolnet (2018), *Israel. Country report on ICT in education*, http://www.eun.org/documents/411753/839549/Israel_2018.pdf/c01cb526-a5d7-469b-b8b1-b67a494d294b (accessed on 1 May 2020). [17]

European Schoolnet (2018), *Spain. Country report on ICT in education*, http://www.eun.org/documents/411753/839549/Country+Report_Spain_2018.pdf/b38b02b0-4b4c-4925-bccd-3b0cf28ad669 (accessed on 1 May 2020). [30]

European Schoolnet (2017), *Belgium - Flanders. Country report on ICT in education*, http://www.eun.org/documents/411753/839549/Country+Report+Flanders+2017.pdf/5dd41869-0b28-4ef5-89c9-c3d4518d5cc4 (accessed on 1 May 2020). [12]

Eurydice (2019), *Digital education at school in Europe*, https://eacea.ec.europa.eu/national-policies/eurydice/content/digital-education-school-europe_en (accessed on May 2020). [10]

Federal Ministry of Education and Research of Germany (2019), *Digital future. Learning. Researching. Knowing*, https://www.bildung-forschung.digital/files/BMBF_Digitalstrategie.pdf (accessed on 1 May 2020). [37]

Government of Australia (2018), *Australia's tech future. Delivering a strong, safe and inclusive digital economy*, https://www.industry.gov.au/sites/default/files/2020-02/national-blockchain-roadmap.pdf (accessed on 1 May 2020). [6]

Government of Hungary (2016), *Digital education strategy of Hungary*, https://www.kormany.hu/download/0/4b/21000/The%20Digital%20Education%20Strategy%20of%20Hungary.pdf (accessed on 1 May 2020). [11]

Government of Mexico (2017), *Educational transformation (Transformación educativa)*, http://gob.mx/mexicodigital/articulos/transformacion-educativa-95278 (accessed on 1 February 2020). [41]

Government of the Republic of Estonia (2018), *Digital agenda 2020 for Estonia*, https://www.mkm.ee/sites/default/files/digitalagenda2020_final.pdf (accessed on 1 May 2020). [3]

Government of the Republic of Portugal (2017), *INCoDe.2030. National digital competences initiative e.2030*, https://www.incode2030.gov.pt/sites/default/files/incode2030_en.pdf (accessed on 1 May 2020). [38]

Government of the Republic of Slovenia (2016), *Digital Slovenia 2020. Development strategy for the information society until 2020*, https://www.gov.si/assets/ministrstva/MJU/DID/Digital-Slovenia-2020-Development-Strategy-for-the-Information-Society-until-2020.pdf (accessed on 1 May 2020). [36]

Hilbert, M. (2015), *Digital Divide(s)*, John Wiley & Sons, Inc., Hoboken, NJ, USA, http://dx.doi.org/10.1002/9781118767771.wbiedcs012. [39]

Holmes, W. (2019), "Artificial intelligence in education.", in *Artificial intelligence in education. Promises and implications for teaching and learning*, Center for Curriculum Redesign, Boston, http://bit.ly/AIED-BOOK. [21]

Hooft Graafland, J. (2018), "New technologies and 21st century children: Recent trends and outcomes", *OECD Education Working Papers*, No. 179, OECD Publishing, Paris, https://dx.doi.org/10.1787/e071a505-en. [32]

Innovation, Science and Economic Development Department of Canada (2018), *Digital literacy exchange program*, http://www.ic.gc.ca/eic/site/102.nsf/eng/home (accessed on May 2020). [42]

Luckin, R. (2016), *Intelligence Unleashed: An argument for AI in education*. [28]

Ministry of Education and Higher Education of Québec (2018), *Digital action plan for education and higher education*, http://www.education.gouv.qc.ca/fileadmin/site_web/documents/ministere/PAN_Plan_action_VA.pdf (accessed on 1 May 2020). [20]

Ministry of Education of Norway (2017), *Digitalisation strategy for basic education 2017-2021*, https://www.regjeringen.no/no/dokumenter/framtid-fornyelse-og-digitalisering/id2568347/ (accessed on 1 May 2020). [44]

Ministry of Education, Culture and Science of the Netherlands (2019), *Digitization agenda. Primary and secondary education*, https://www.rijksoverheid.nl/binaries/rijksoverheid/documenten/publicaties/2019/03/22/digitaliseringsagenda-primair-en-voortgezet-onderwijs/OCW+Digitization+Agenda+-+English.pdf (accessed on 1 May 2020). [13]

Ministry of Education, Culture, Sports, Science and Technology of Japan (2019), *Promoting measures to utilise cutting-edge technology to support learning in a new era*, https://www.mext.go.jp/a_menu/other/1411332.htm (accessed on 1 May 2020). [9]

Ministry of National Education and Ministry of Higher Education of France (2018), *Digital in the service of the school of trust*, https://cache.media.education.gouv.fr/file/08_-_Aout/36/1/DP-LUDOVIA_987361.pdf (accessed on 1 May 2020). [23]

Ministry of National Education of Turkey (2019), *Turkey's education vision*, http://2023vizyonu.meb.gov.tr/doc/2023_vizyon_eng.pdf (accessed on 1 May 2020). [18]

OECD (2019), *Artificial Intelligence in Society*, OECD Publishing, Paris, https://dx.doi.org/10.1787/eedfee77-en. [22]

OECD (2019), *Digital Innovation: Seizing Policy Opportunities*, OECD Publishing, Paris, https://dx.doi.org/10.1787/a298dc87-en. [4]

OECD (2019), *OECD Employment Outlook 2019: The Future of Work*, OECD Publishing, Paris, https://dx.doi.org/10.1787/9ee00155-en. [31]

OECD (2019), *OECD Skills Outlook 2019 : Thriving in a Digital World*, OECD Publishing, Paris, https://dx.doi.org/10.1787/df80bc12-en. [1]

OECD (2018), *OECD Blockchain primer*, http://www.oecd.org/finance/oecd-blockchain-primer.pdf. [25]

OECD (2017), *OECD Digital Economy Outlook 2017*, OECD Publishing, Paris, https://dx.doi.org/10.1787/9789264276284-en. [5]

Suhonen, J. (2006), "FODEM: developing digital learning environments in widely dispersed learning communities", *Educational Technology & Society*, pp. 43-55, https://www.researchgate.net/publication/220040754. [16]

UNESCO (2019), *Artificial Intelligence in Education: Challenges and Opportunities for Sustainable Development*, https://unesdoc.unesco.org/ark:/48223/pf0000366994 (accessed on May 2020). [40]

Vincent-Lancrin, S. et al. (2019), *Fostering Students' Creativity and Critical Thinking: What it Means in School*, Educational Research and Innovation, OECD Publishing, Paris, https://dx.doi.org/10.1787/62212c37-en. [34]

Vincent-Lancrin, S. et al. (2019), *Measuring Innovation in Education 2019: What Has Changed in the Classroom?*, Educational Research and Innovation, OECD Publishing, Paris, https://dx.doi.org/10.1787/9789264311671-en. [2]

World Economic Forum (2018), *The Future of Jobs Report 2018*, World Economic Forum, http://www3.weforum.org/docs/WEF_Future_of_Jobs_2018.pdf. [33]

Annex A. Oversight per country/economy

This annex is meant to give a brief overview of digital education policies in OECD countries and economies

Table A A.1. Oversight per country

Country	Digital education strategy	Generic digital strategy	Online information

AUSTRALIA	Education for a changing world. Policy reform and innovation strategy (New South Wales Government 2019), [link]
	• Skills
	  ○ Curriculum
	  ○ 21st century skills, e.g. critical and computational thinking
	• Assessment
	• New educational approaches
	  ○ applied learning (e.g. integrating real life problems into existing subjects)
	  ○ technology-enabled personalisation
	  ○ integrated extra-curricular activities.
		Australia's tech future. Delivering a strong, safe and inclusive digital economy (Department of Industry, Science, Energy and Resources 2018), [link]
		• Skills
		  ○ national curriculum
		  ○ flexibility, micro-credentials
		  ○ key digital skills (incl. artificial intelligence (AI), machine learning (ML), robotics)
		• Inclusion
		  ○ increasing accessibility through digital technologies
		• Digital infrastructure
		  ○ e.g. programme for regional and remote areas
		• Data
		  ○ open data (data.gov.au), enhanced access, privacy and security
		• Regulation
			Digital learning (Victoria), [link]
			• Online materials and tools

Country	Digital education strategy	Generic digital strategy	Online information

AUSTRALIA (cont.)	Digital strategy 2019-2023. IT's all connected: for creative, connected and engaged learners now and in the future (Queensland Department of Education 2019), [link]
	• ICT infrastructure and devices
	  ○ secure and seamless by design digital environments
	  ○ scale networks to Internet of Things
	• Enhanced collaboration
	  ○ interoperability standards, open data
	  ○ virtual spaces and classrooms, improved video, audio and chat tools
	• Skills and digital literacy.
		The national blockchain roadmap: progressing towards a blockchain-empowered future (Department of Industry, Science, Energy and Resources 2020)
		• Credentialing	

AUSTRIA	Masterplan digitalisation (Masterplan Digitalisierung) (Bundesministerium für Bildung, Wissenschaft und Forschung 2018), [link]
	• Skills
	  ○ curriculum
	  ○ teacher training
	• ICT infrastructure
	  ○ digital teaching and learning tools
	  ○ roll-out digital devices
	  ○ broadband, fiber optic connection, Wi-Fi
	• Simplify school administration
		Digital roadmap Austria (Bundeskazleramt 2017), [link]
		• Skills
		reference framework
		• Open digital resources
		  ○ open licenses
		  ○ digital and interactive school books
		  ○ open source software
		• Innovative educational technologies
		  ○ e.g. flipped classroom
		• Foundation for Innovation in Education (EUR 50 million)
		• ICT infrastructure
		  ○ Wi-Fi and broadband
			N/A

BELGIUM	Baromètre digital Wallonia. Éducation et numérique 2018 (Wallonia digital barometer. Digital education) (Agence du Numérique 2018), [link]
	• ICT infrastructure
	  ○ devices (computers, whiteboards, other equipment), BYOD
	  ○ Internet connections, Wi-Fi
	• Skills
	  ○ teacher training
	  ○ numerical competency
	• Digital learning environment
	  ○ digital platforms for educational institutions: tools, clouds
		Flemish AI policy plan (Vlaams beleidsplan artificiële intelligentie) (Vlaamse Regering 2019), [link]
		Flemish cybersecurity policy plan (Vlaams beleidsplan cybersecurity) (Vlaamse Regering 2019), [link]
		• STEM and digital education
		  ○ project Schools of the Future
			European Schoolnet, Belgium – Flanders. Country report on ICT in education (2017)
			i-Learn (Flemmish Community) [link]
			Project to create online portal for digital (personalised) learning

Country	Digital education strategy	Generic digital strategy	Online information

CANADA	Learning and technology policy framework (Alberta Government 2013), [link]
	• Skills
	  ○ training for teachers and other education professionals
	  ○ professional standards
	  ○ education leaders 'champion effective and innovative uses of technology'
	• Curriculum (e.g. programs of study, assessment)
	• Digital resources and ICT infrastructure
	• High-quality digital learning environments
		Canada's digital charter in action: a plan by Canadians, for Canadians (Government of Canada 2019), [link]
		• ICT infrastructure, reliable and affordable high-speed Internet access
		• Online educational resources
			Digital Literacy Exchange Program [link]
			• CAD 29.5 million investment to support initiatives that teach fundamental digital literacy skills (2018-2022)
			• Part of Canada's Skills and Innovation Plan
			E-learning Ontario [link]
			• Digital learning environment (learning management system)
			• Educational resource bank
			• E-community

	Digital action plan for education and higher education (Ministère de l'Éducation et de l'Enseignement supérieur Québec 2018), [link]
	• Skills
	  ○ leadership and professional development
	• Bridging digital divide
	• ICT infrastructure
	• Use digital technologies for innovative teaching and learning practices
	  ○ e.g. MOOCs, gamification, VR/AR, tablets and e-books, flipped classroom, wearable technology, 3D, BYOD, etc.
	• CAD 1.186 billion to implement digital action plan (2018-2023)
			Digital literacy framework (British Columbia) [link]
			• Digital literacy and skills (e.g. creativity and critical thinking, digital citizenship)
			• Reference framework

CHILE	N/A	Digital agenda 2020 (Government of Chile 2015), [link]
		• Digital content + pedagogical-technological innovation in education system
		  ○ digital kit for students with special needs
		• Digital training
			Educar Chile [link]
			• Online education portal
			  ○ focus on remote and low-income areas with less access to resources
			Recommendations for a digital policy in school education [link]

CZECH REPUBLIC	Digital literacy strategy 2015-2020 (Strategie digitální gramotnosti ČR na období 2015 – 2020) (Ministry of Labour and Social Affairs), [link] • Digital literacy	N/A	Czech national digital skills and job (DIGI) coalition, [link], [link] • Digital skills

Country	Digital education strategy	Generic digital strategy	Online information
DENMARK	N/A	Strategy for Denmark's digital growth (Danish Government2018), [link] • (plans for) Technology Pact: strengthening technical and digital skills • Primary and secondary education: technological understanding (curriculum) • DKK 50 million for digital technologies initiatives in universities • 20 million for development of virtual education technologies (higher education) • Digital skills • Higher education in STEM subjects • DKK 43.4 million to improve coordination of (continuing) education across trade and industry to support technological and digital skills	European Schoolnet, Denmark. Country report on ICT in education (2017)

ESTONIA	N/A	Digital agenda 2020 for Estonia (Government of the Republic of Estonia 2018), [link]
		• Teachers' and students' ICT competency, basic ICT skills in schools
		  ○ cyber defence education in schools
		• Technology education in pre-primary education level
		• Resources
		• IT Academy programmes to develop ICT in vocational and higher education
			e-Estonia, [link]
			• Education Information System
			  ○ state database with data on institutions, students, teachers, graduation documents, study materials, curricula (since 2005)
			• eKool and Stuudium
			  ○ web applications for parents, teachers and children to collaborate and organise teaching and learning information
			• Research Information System
			  ○ national information system for research and development – submit applications for grant competitions, upload CV's, etc.
			• e-Schoolbag and other e-school solutions
			  ○ portal for digital learning materials
			  ○ further: eKindergarten for innovative and digital solutions for pre-schools to organize daily work; unrestricted access to certain learning materials; platform with games, 3D models, videos, etc. to help students and monitor their performance; Roboversity to make students enthusiastic about robots

Country	Digital education strategy	Generic digital strategy	Online information
EUROPEAN UNION	Digital education action plan (European Commission 2018), [link] • Connectivity in schools • SELFIE tool for 'self-reflection' on the use of digital technologies for teaching and learning • Digital qualification documents, issued by education and training institutions, based on open standards and integrated in the Europass platform • Higher education hub – online platform to improve quality of teaching and learning, facilitate internationalisation and support cooperation across Europe • Digital competences and open science skills in higher education • AI and analytics pilot projects to predict future skills and skills shortages	N/A	Eurydice, Digital education at school in Europe (2019), [link]
			European Commission, Supporting teacher competence development for better learning outcomes (2013) • Reference framework for teacher competences
FINLAND	N/A	Leading the way into the age of artificial intelligence. Final report of Finland's Artificial Intelligence Programme 2019 (Ministry of Economic Affairs and Employment 2019), [link], [link] • Recommendations on high-quality education and training for AI, including vocational education; raising the level of education to match skills	European Schoolnet, Finland. Country report on ICT in education (2017)
		Digital infrastructure strategy 2025 (Ministry of Transport and Communications 2018), [link] • High-speed communications networks	MPASSid, [link] • National identification service for continual learning; single sign-on access to all digital services used in teaching and learning
			Avointen oppimateriaalien kirjasto (Library of open educational resources), [link] • Open educational resources from all levels of education, available for use by teachers, learners and others
			EXAM, [link] • Software for higher education, developed and used by a consortium of Finnish universities for organising electronic exams in monitored exam studios, or by other means (e.g. BYOD)

Country	Digital education strategy	Generic digital strategy	Online information
			Digi Arkeen (Digi Everyday), [link] • Advisory board for the cooperation and dialogue between the Ministry of Finance and other organisations that are responsible for the digitalisation of public services
			Koski, [link] • National study credit, degree and qualification disclosure service that provides comprehensive access to data • National education data warehouse
			Vocabulary of Education project, [link] • Project to lay a foundation for developing online services and creating an information architecture in the field of education and research, and to help with the flow of communication between information systems and those producing, using and searching for information
FRANCE	Digital in the service of the school of trust (Le numérique au service de l'école de la confiance) (Ministère de l'Éducation Nationale and Ministère de l'Enseignement Supérieur, de la Recherche et de l'Innovation 2018), [link] • Protection and improved use of educational data • General interest in development of AI (improved learning and assessment, relieve teachers of tedious tasks), IoT, blockchain, free and open resources • Digital resource bank • National Center for Distance Education (October 2018) • Support for digital skills • Simplify administrative formalities for students and parents • Support partnerships between companies and schools	For a meaningful artificial intelligence. Towards a French and European strategy (Villani report) (2018), [link]	

Country	Digital education strategy	Generic digital strategy	Online information
GERMANY	N/A	Digital future. Learning. Researching. Knowing (Digitale Zukunft: Lernen. Forschen. Wissen. Die Digitalstrategie des BMBF) (Bundesministerium für Bildung und Forschung 2019), [link] • Digital competences • Prevention of digital divides • Vocational Training 4.0 initiative ○ promote use of digital media, digital equipment for vocational training centers • MINT action plan for STEM • Basic digital education project, digital environments • central building blocks as digital architecture: online administration of digital educational data on voluntary basis, individual opportunities for tailored education	Digital pact schools (DigitalPakt Schule), [link] • EUR 5 billion investment in digital education infrastructure
GREECE	N/A	Digital skills for digital Greece. Action Plan 2019 for the promotion of innovation and digital skills (Ministry of Administrative Reconstruction 2019), [link] • Skills: information and data literacy, communication and collaboration, digital content creation, safety, problem solving • Digital skills in education = third priority • Actions with regard to coding, teaching with new technologies, robotics, etc.	Digital school, [link] • Teacher training • e-repository of text books • Computer laboratories

HUNGARY	Digital education strategy of Hungary (Government of Hungary 2016), [link]
	• Digital competences, skills
	  ○ teacher training, reference framework
	• ICT infrastructure
	  ○ internet access, WiFi
	  ○ high quality of IT devices
	  ○ equipment for specialised classrooms: 3D printers, programmable robots, digital data loggers and sensors in science classrooms, multimedia labs
	• Development of digital content
	  ○ wide range of e-learning materials should be available
		N/A	N/A

Country	Digital education strategy	Generic digital strategy	Online information

HUNGARY (cont.)	• Support services
	  ○ digital administration, electronic data provision
	  ○ electronic platforms for contact with students and parents, digital learning and teaching activities
	• Knowledge base for data in public education, available to decision-makers
	• Digital Methodological Centre to coordinate strategy		

ICELAND	N/A	Icelandic society 2035-2040. Economic, environmental, regional, and demographic developments (Government of Iceland 2019), [link] • Emphasis on core knowledge, skills, and competencies • More students should specialise in science, technology, engineering, art, and mathematics (STEAM)	N/A

IRELAND	Digital strategy for schools 2015-2020. Enhancing teaching, learning and assessment (Department of Education and Skills 2015), [link]
	• ICT competences
	  ○ teacher learning
	  ○ digital literacy in the curriculum, assessment reform
	  ○ inclusion
	• ICT infrastructure
	  ○ improve broadband connections in primary schools, provide wirless networks at new-build stage, technical guidance documents for schools, procurement framework for wireless providers
	  ○ advice on ICT equipment, guidance for BYOD approaches
	  ○ explore potential of cloud-based services
	• Awareness-raising actions and programmes to promote responsible and ethical use of the Internet
		N/A	Scoilnet, [link]
			• Digital portal for education

Country	Digital education strategy	Generic digital strategy	Online information
ISRAEL	N/A	The digital Israel national initiative. The national digital program of the government of Israel (Ministry for Social Equality 2017), [link] • Narrowing social gaps • Digital literacy among weakened populations • Access to quality public goods and services by digital means • Digital books program • Digital skills, online occupational training • Programming and robotics in curriculum • ed.il community for hackathons and competitions in the education field • National digital learning project (platform)	European Schoolnet, Israel. Country report on ICT in education (2018)

ITALY	National plan for digital education (Piano nazionale scuola digitale) (Ministry of Education, Universities and Research 2015), [link]
	• Vision on digital schools: digital opportunities as enabling tools, connectors and drivers of change
	  ○ projects categorised in: tools, skills and content, training, and accompaniment
	• Access: 'right to Internet', fiber for ultra-wide bandwidth for schools
	• Digital environments, guidelines for BYOD policies
	• Digital profile for students and teachers
	  ○ unique authentication system
	• Digitization of school administration and teaching processes
	• Common framework for digital skills of students, update technology curriculum
	• Bridge digital divides
	• Promote science, technology, engineering, arts and maths (STEAM) careers
	• Promote innovation, diversity and sharing of educational content
		N/A	N/A

Country	Digital education strategy	Generic digital strategy	Online information
ITALY (cont.)	• Minimum standrds for e-interoperability • Promotion of open educational resources • In-service training for didactic and organizational innovation, technical assistance for schools	N/A	N/A
JAPAN	Promoting measures to utilize cutting-edge technology to support learning in a new era (Ministry of Education, Culture, Sports, Science and Technology 2019), [link] • IoT, AI, advances in robotics, use of (big) data, AR/VR • Ensure basic skills • Promote individual learning • Use cutting-edge technology and big data sets, based on digital environments • Opportunities for children with special needs and learning disabilities • Improve ICT environments and equipment, improve effective use ○ digital textbooks and teaching materials		
KOREA	N/A	Mid- to long-term master plan in preparation for the intelligent information society. Managing the fourth industrial revolution (Government of the Republic of Korea 2016), [link] • Foster creativity and technological capacity	N/A
LUXEMBOURG	N/A	N/A	Digital4Education, [link] • digital environment, e.g. for mobile learning, digital classroom, digital resources, education on technologies and data, digital challenges (cyberbullying, security) • projects: eduSphere (online teaching and learning platform), AI Academy

Country	Digital education strategy	Generic digital strategy	Online information

NETHERLANDS	Digitization agenda. Primary and secondary education (Ministry of Education, Culture and Science 2019), [link]
	• Innovation by learning for teachers, school principals and administrators
	  ○ e.g. by effective use of adaptive learning resources which meet pupils' learning needs and style of learning
	  ○ open innovation climate, cooperation between education and businesses
	• Digital literacy for pupils and teachers
	  ○ curriculum
	• Digital learning resources
	  ○ collaborating school boards in educational resources market (joint purchase)
	  ○ open-access educational resources
	• Infrastructure
	• Ethics, privacy
		Strategic action plan for artificial intelligence (Ministry of Economic Affairs and Climate 2019), [link]
		• Training opportunities for living with AI and more talent for working with AI
		• STAP (Labour Market Position Stimulus): EUR 200 million for individual budgets for training and development
		• Focus on (senior) secondary vocational education, e.g. by subsidies (EUR 25 million a year until 2022) for improving the connection with the labour market, e.g. for projects that offer training in a profession that has changed as a result of AI
			Kennisnet, [link]
			• Publications (in English and Dutch) about ICT infrastructure and digital technologies (e.g. trends, challenges) in education

NEW ZEALAND	N/A	N/A	Education Review Office, Leading innovative learning in New Zealand schools (2018)

NORWAY	Digitalisation strategy for basic education 2017-2021 (Digitaliseringstrategi for grunnopplæringen 2017-2021) (Ministry of Education 2017), [link]
	• Students', teachers' and staff competence
	  ○ curriculum
	  ○ specialist education for teachers (60 credits)
	• Privacy and security
	• ICT infrastructure, technology-rich learning environments
	• Learning content, digital learning resources (e.g. for students with special needs)
	• Effective use of devices
	
	Digitalisation strategy for the higher education sector 2017-2021 (Ministry of Education and Research 2017), [link
		N/A	N/A

POLAND	N/A	N/A	The digitalisation of Polish education. Visions and proposals (2016), [link]

Country	Digital education strategy	Generic digital strategy	Online information

PORTUGAL	Portugal INCoDe.2030. National digital competences initiative e.2030 (Government of Portugal 2017), [link]
	• Digital competences, 5 axes : inclusion, education, qualification, specialisation, research
	  ○ inclusion: ensure whole population has equal access to digital technologies
	  ○ education: ensure education of younger population
	  ○ qualification: build the (digital) skills of an active population
	  ○ specialisation: promote specialisation in digital technologies and applications
	  ○ research: ensure conditions re in place for production of new knowledge and active participation in international R&D networks and programmes
		N/A	N/A

SLOVENIA	N/A	Digital Slovenia 2020. Development strategy for the information society until 2020 (Government of Slovenia 2016), [link] • Generic strategy with regard to subjects like interoperability, ICT infrastructure, cyber security, inclusive digital society • Digital literacy and ICT skills	Monitoring progress in national initiatives on digitising industry. Country report Slovenia (July 2019), [link] • Mentions Slovenian guidelines on further implementation of ICT in the Slovenian education until 2020
SPAIN	N/A	N/A	European Schoolnet, Spain. Country report on ICT in education (2018)
SWITZERLAND	N/A	Digitisation challenges for education and research in Switzerland (Herausforderungen der Digitalisierung für Bildung und Forschung in der Schweiz) (Department of Economics, Education and Research 2017) [link] • ensuring core values: equal opportunities; security, trust and transparency; digital empowerment (skills); and value creation, growth and prosperity • high-quality, efficient and secure ICT infrastructure; standardisation	N/A

Country	Digital education strategy	Generic digital strategy	Online information

TURKEY	Turkey's education vision 2023 (Ministry of National Education 2019), [link]
	• Data-based management with learning analytics tools
	  ○ Learning Analytics Platform
	  ○ Data Control Unit, Educational Data Warehouse
	• Measurement and evaluation
	  ○ e-portfolio for each child, Qualification-Based Evaluation System to identify and monitor children
	  ○ restructuring exam system
	• Professional development teachers
	• National Digital Content Archive
	• Skills; coding and 3D design activities
		N/A	N/A

UNITED KINGDOM	Realising the potential of technology in education: A strategy for education providers and the technology industry (Department for Education 2019), [link]
	• 5 key areas of opportunity: administration processes (reduce burden of 'non-teaching' tasks), assessment processes (making assessments more effective and efficient), teaching practices (supporting access, inclusion, and improved educational outcomes for all), continuing professional development (supporting teachers), and learning throughout life
	• IT infrastructure
	  ○ (general goal: nationwide full-fibre by 2033)
	  ○ support Jisc, independent organisation that provides digital infrastructure and services for higher and further education
	  ○ guidance documents for schools
	  ○ cloud first policy
		UK digital strategy 2017	N/A

Country	Digital education strategy	Generic digital strategy	Online information

UNITED KINGDOM (cont.)	• Digital capability and skills
	  ○ launching network of demonstrator schools
	  ○ continuing professional development
	• Digital procurement capabilities
	  ○ recommended buying deals for schools, facilitate online marketplace for EdTech
	  ○ online lending library for EdTech software
	  ○ boosting UK EdTech sector, UK as world leader
	• Privacy, safety and data security		

UNITED STATES	Reimaging the role of technology in education: 2017 national education technology plan update (Department of Education 2017), [link]
	• Empower learning through technology: high-speed internet access, personalized learning, blended learning, building competencies
	  ○ focus on new technologies, e.g. virtual learning labs, use of games and simulations, new ways to connect physical and virtual interaction, AR
	  ○ equity, closing digital use divide (accessible technology)
	• Teaching with technology: teacher training, advancing educational technology in teacher preparation, ongoing professional learning
	• Leadership (creating culture and conditions for innovation and change)
	  ○ openly licensed educational resources
	  ○ federal funds to support technology-based strategies to personalise learning
		N/A	N/A

Country	Digital education strategy	Generic digital strategy	Online information

	• Assessment
	  ○ enable enhanced question types, measure complex competencies, provide real-time feedback, increase accessibility, adapt to learner ability and knowledge, embedded with learning process, assess for ongoing learning
	  ○ continuous improvement of assessments, integrated learning and assessment systems, using data effectively and appropriately, learning dashboards that enable visualisations, set of shared skill standards
	• Infrastructure: ubiquitous connectivity, powerful learning devices, high-quality digital learning content, responsible use policies		