1 Building a digital education policy ecosystem for quality, equity and efficiency

This chapter introduces the enabling factors for quality, equity and efficiency of digital education. It presents the framework guiding this report, covering its analytical dimensions and policy levers, levels of analysis and outcomes. The chapter also defines key terms related to digital education and digital technologies that are used throughout the report and presents a short overview of what will be covered in the following chapters.

Introduction

Digital technologies are a key resource for OECD education and training systems. Over the past decade, investment in education technology has surged worldwide and digital technologies increasingly permeate schools and classrooms (IDB and HolonIQ, 2021[1]). The COVID-19 pandemic has accelerated this development and led to an unprecedented increase in the use of digital education technologies, enabling the continuation of instruction while education institutions were closed. Throughout education systems, there is a growing expectation that digital education tools are here to stay and that their role in teaching and learning will continue to expand in the future. While the experience of the past few years has given us a glimpse of the potential of digital education technologies, it has also cast light on some of the risks associated with their unregulated use and showed that many education systems are far from providing equitable access to high-quality digital technologies. These developments raise the question of how education systems can harness the full potential of digital education, while mitigating associated risks.

There is a broad consensus that the use of digital education technologies should not be an end in itself but serve the wider goals of education systems. This report focuses on policies that can enable digital education technologies to contribute to three goals that are widely shared among OECD education systems: quality, equity and efficiency. If enabling conditions are in place to support their effective use, digital education technologies have the potential to enhance the impact of teaching and learning along each of these dimensions, by enhancing the quality of teaching and students' learning experience, by promoting equity, access and inclusion through personalised learning tools and assistive technologies, and by saving costs and making educators' work more efficient.

If used effectively, digital technologies can enhance educators' ability to provide high-quality instruction and to better meet all students' learning needs and interests by providing more differentiated instruction (Ganimian, Vegas and Hess, 2020[2]; Røe, Wojniusz and Bjerke, 2022[3]). The use of digital education technologies has also been credited for its potential to enable a more engaging and enjoyable learning experience, to promote the development of non-cognitive skills, and to broaden students' horizons by letting them engage with people and ideas from across the world (OECD, 2020[4]). In addition, digital platforms can widen educators' and students' access to learning materials and make learning environments more inclusive through the use of advanced assistive technologies (ICF Consulting Services Ltd, 2015[5]).

At the same time, the digital transformation has a profound impact on the types of skills and attitudes that students will need to thrive in later life. Digital technologies will play a crucial role for education institutions to respond to these developments, to cater to their students' changing needs and to prepare them for the challenges they will face in fast-evolving economies and societies. A more detailed review of the evidence concerning the impact of digital technology on quality, equity and efficiency in education is presented at the end of this chapter.

Notwithstanding the potential benefits of digital technologies for teaching and learning, education systems are far from exploiting their full potential and the challenges and risks inherent in their use have been extensively documented (OECD, 2019[6]; OECD, 2021[7]; Bulman and Fairlie, 2016[8]). Without an enabling policy environment and capacity building at all levels of the education system, investments in education technology are unlikely to pay off and have the desired effect on student learning. Critics have also warned of unintended consequences and the potentially harmful effects that the unthinking use of digital technologies could have on the quality of instruction and educators' professionalism. Moreover, the use of advanced technologies in education prompts questions regarding the necessity of human oversight in the light of algorithmic bias, and the extent to which education systems should rely on digital technologies (e.g. assessment or early-warning systems) for high-stakes decisions. Rapid technological advances in the field of AI in particular raise a number of questions and dilemmas concerning the regulation of the use of AI in schools (including its implications for assessment practices and intellectual property) and the types

of skills that education systems should aim to develop, given the rapidly advancing capabilities of AI and its implications for the future of work (OECD, 2023[9]).

In light of the significant challenges and opportunities related to digital education technologies, it is imperative to create the conditions that can enable actors at all levels of the education system to make the most of digital education. Prior research and analyses on the use of digital technologies in education have focused on the availability, use and effectiveness of digital resources in the classroom. Much less attention has been paid to the role system-level policies play in supporting or impeding the effective and equitable use of digital resources in education.

This report seeks to provide the foundation for future work to fill this gap. It takes stock of what we know about digital education policies and investigates promising international practices to support countries in designing a comprehensive and integrated system-level policy environment that enables an effective and equitable use of digital technologies in education.

As such, the focus of this report lies in providing guidance to policy makers on how to optimise the use of digital technologies in the short- and medium run. In the longer run, education systems might undergo substantive changes in terms of the spaces and formats in which learning takes place, the relevant education actors and how they relate to each other. Digital technologies have the potential to contribute to these changes. Recent advances in AI technology (e.g. ChatGPT) have provided first indications of how digital technologies might challenge and potentially reshape education systems going forward. Whilst other OECD projects (OECD, 2021[10]; OECD, 2020[11]) are investigating frontier uses of digital technologies and their impact on education systems in the long run, this report is primarily concerned with the immediate policy implications of digital technologies within the existing institutional arrangements of OECD and EU education systems.

Policy makers face significant challenges to realise the potential of digital technologies within the existing frameworks of education systems. To map out policy areas that need to be mobilised for effective digital education, the following sections of this chapter present an analytical framework covering digital education policies along eight analytical dimensions:

1. Strategic visions and policy co-ordination for digital education
2. Pedagogical approaches, curricula and assessment for digital education
3. Governance, guidance and regulatory frameworks for digital education
4. Funding and procurement for digital education
5. Infrastructure and innovation for digital education
6. Capacity building for digital education
7. Human resource policies for digital education
8. Monitoring and evaluation of digital education

The remaining chapters of the report look at each of these dimensions in turn, taking stock of the available empirical evidence, policy practices in OECD countries and the main challenges that policy makers are currently facing. Each chapter then discusses a number of policy levers and examples of promising approaches that could help countries to unlock the potential of digital education technologies and promote educational quality, equity and efficiency through digital education.

Analytical framework for a digital education policy ecosystem

Enabling education systems to achieve excellence and equity in the digital age requires a holistic policy approach. To guide its analysis, the report proposes an analytical framework that reflects the wide-ranging

and complex implications of digitalisation for students, teaching staff, education institutions and the broader education ecosystem (Figure 1.1 and Figure 1.2).

The analytical framework is designed to:

- be holistic and to cover the full range of policies that are needed for successful digital education. The analytical framework therefore considers a large number of policy levers within the realm of education, which are organised around eight analytical dimensions, as well as their interaction with the broader policy ecosystem.
- facilitate an analysis of the implications of digital education policies across all levels and for a wide range of actors within and outside of the education system. The analytical framework therefore comprises several levels of analysis, ranging from the student level to stakeholders in the broader digital education environment (e.g. EdTech companies).
- highlight the wide range of outcomes that digital education policies can influence. The analytical framework therefore considers the effects of digital policy levers on different types of outcomes (including cognitive and socio-emotional skills, well-being and social outcomes), along three dimensions: quality, access and equity, and efficiency.

The framework's analytical dimensions and policy levers, its levels of analysis, and the digital education outcomes that it covers are described in more detail in the following sections.

Figure 1.1. Analytical framework for a digital education policy ecosystem: Overview

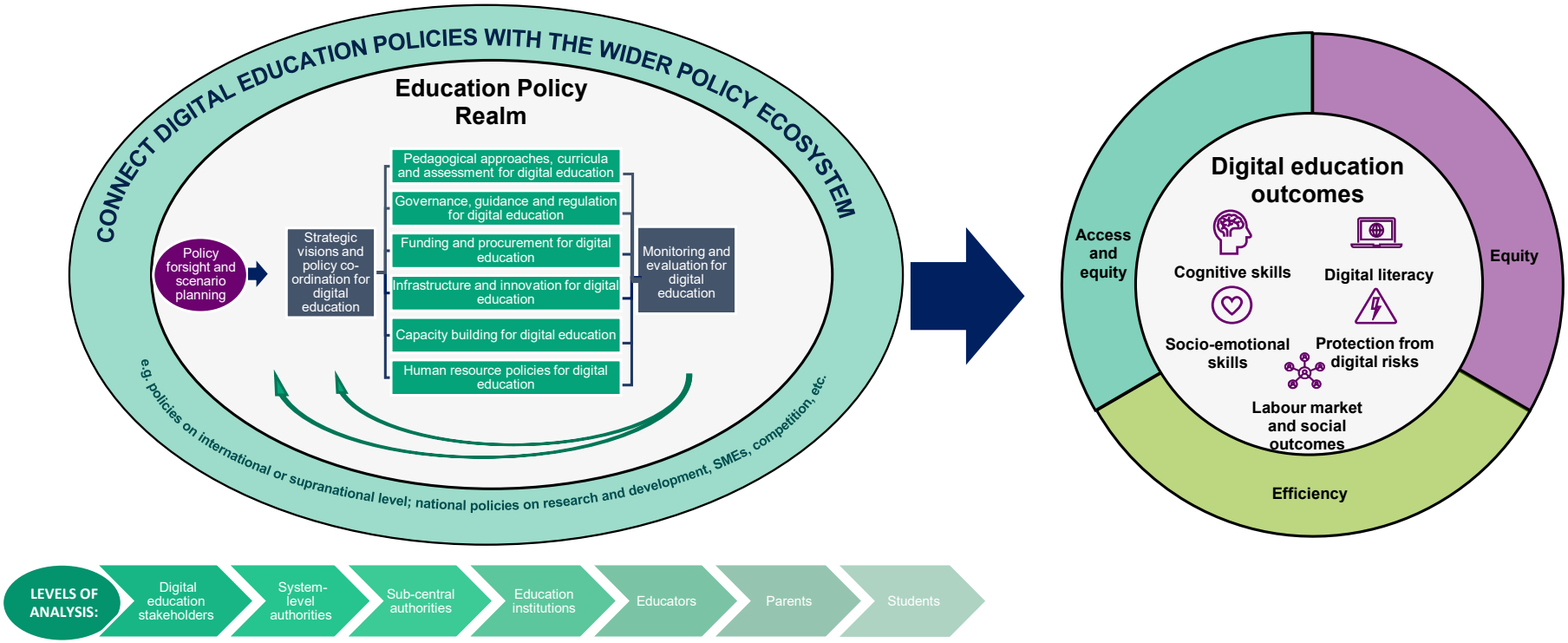
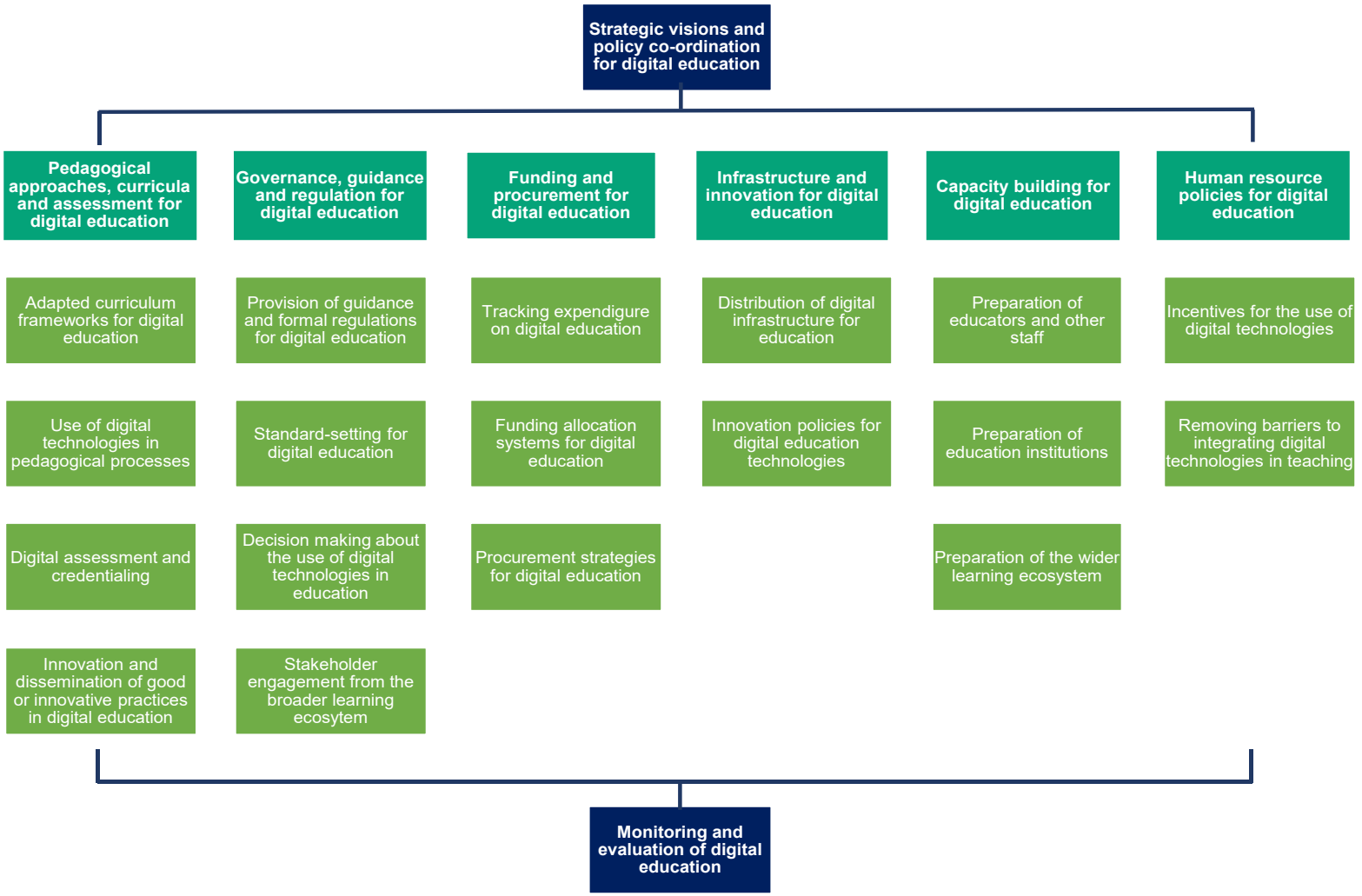


Figure 1.2. Analytical framework for a digital education policy ecosystem: Analytical dimensions and policy levers



The scope of the analytical framework and this report covers policies related to digital education in primary and secondary schooling, VET, and higher education offered by education institutions. Digital education, in the context of this report, is understood to encompass all forms of teaching and learning enhanced by the use of digital technologies, including online, hybrid and blended education. Digital technologies are broadly defined to include networks (e.g. Internet), hardware, software and technology-related services (see Annex 1.A for detailed definitions of key terms). The report focuses on the educational uses of these digital technologies, rather than on their other possible functions (such as institutional planning, business processes, the management of physical and human resources, or research).[1]

The framework was developed building on a range of evidence from research and on international digital education policies as well as general resourcing policies for education systems. It takes into account identified best practices for digital education policy, as highlighted in evidence on the digital transformation of education systems, as well as existing digital competence frameworks (Vuorikari et al., 2022[12]; European Commission, n.d.[13]; Redecker, Punie and European Commission. Joint Research Centre., 2017[14]). The framework is also informed by other policy projects focused on topics relevant for digital education, e.g. the OECD School Resources Review (OECD, 2013[15]) and the OECD Strength through Diversity project (Cerna et al., 2021[16]).

The evidence reviewed for this project shows substantial differences in education systems' governance structures and in the levels of digital maturity between, and within, different sectors of the education system. The stage of digital maturity of education systems has implications for the sequencing and timing of digital education policies included in the analytical framework. Therefore, all policy levers in the framework, as well as their timing and sequencing, do not apply equally to countries according to their level of digital development.

Analytical dimensions and policy levers

Successful digital education requires leveraging a wealth of policy levers operating at different levels of intervention and impacting different players of the education system (e.g. students, teachers, education institution leaders, public authorities). While some of these policy levers belong to the domain of education policy, others depend on other policy areas and require co-ordination with authorities in charge of other sectors. Similarly, policies for digital education must be considered within the context of the specific education governance environments within which they function and dynamically respond to the new opportunities and needs that arise from emerging technologies. The success of digital education policies must ultimately be assessed against their contribution to a broad range of education outcomes, requiring an understanding of the multifarious ways in which policies for digital education interact with other policies to improve student skills, well-being, and broader social and labour market outcomes.

To navigate these complexities, a well-functioning digital education policy ecosystem (Figure 1.1) must be centred around a **strategic vision for digital education**, which sets out concrete policy measures for digital education and connects them to education system goals. The strategic vision should be linked to mechanisms for policy co-ordination to ensure that education-specific policies harmonise with the wider policy ecosystem to successfully implement digital education. This includes co-ordination within the education realm (e.g. with other education priorities or strategies), across different policy dimensions and layers of the system (e.g. with different relevant actors for digital education) as well as outside of the education realm (e.g. with other policy sectors). In addition, a strategic vision for digital education must include mechanisms for foresight and scenario planning to proactively address future societal, technological and economic changes. Further information on strategic planning for digital education will be discussed in Chapter 2.

Education policy makers can leverage a range of policy levers to achieve their strategic vision for digital education. The analytical framework organises these policy levers along eight analytical dimensions (corresponding to the dark green boxes in Figure 1.2), each of which is discussed in detail in one of the

chapters of this report. Apart from the strategic vision for digital education, these analytical dimensions include:

1. **Adapting pedagogical approaches, curricula and assessments** including policies to support the selection of suitable digital education technologies, the dissemination of effective pedagogical practices involving digital tools, the adaptation of curricula and assessment frameworks and strategies to overcome barriers that limit the take-up and effective use of digital technologies for teaching and learning.
2. **Governance, guidance and regulation for digital education**, providing guidance, standards and legal regulations that support the efficient and safe use of digital education technologies; establishing responsibilities for decision-making related to digital education and designing participatory mechanisms for stakeholder engagement and co-ordination with the private sector.
3. **Funding and procurement for digital education** including efforts to increase transparency and efficiency of spending on digital education, designing funding frameworks to back up digital education policy objectives with the necessary financial resources and supporting better institutional procurement strategies and budget practices.
4. **Infrastructure and innovation for digital education** through policies to ensure equitable access to and adequacy of digital education technologies for students and education institutions. This includes distribution mechanisms for digital education technologies that allow achieving desired policy targets such as strategies to bridge digital divides between education institutions. It also requires multi-dimensional and co-ordinated policy efforts to support innovation for digital education technologies (e.g. tax incentives, grants for business R&D and innovation, reducing regulatory burdens for start-ups).
5. **Capacity building for digital education** among educators, education institutions and actors across the wider learning ecosystem (including specialist staff, parents and local administrators). The dimension considers a range of policy levers ranging from the initial education and continuing professional learning of educators (including the support of peer learning and communities of practice). It also considers how governments can provide education institutions with guidance on the integration of digital education technologies, support their leadership and strengthen their ability to engage in institutional improvement strategies in the area of digitalisation.
6. **Human resource policies for digital education** such as adapting career structures, progression criteria and working time arrangements to empower and incentivise educators to effectively employ digital technologies in their teaching practices.

A final analytical dimension relates to **monitoring and evaluation**. To ensure that the policy levers described above work effectively and generate desirable education outcomes, education policy makers must put in place adequate structures for monitoring and evaluation. This entails designing a holistic monitoring and evaluation framework which is in line with national objectives and developing sources of evidence on the progress and effects of digital education policies. Insights gained through monitoring and evaluation should feed back into the strategic vision and influence the direction of future policies for digital education. Effective monitoring and evaluation provisions for digital education are discussed in Chapter 9.

While the analytical framework proposes a comprehensive list of policy levers for digital education, it is important to recognise that the extent of action that might be taken with respect to different policy levers will vary across countries depending on their level of digital development. Education systems stand at different levels of digital development, although the COVID-19 pandemic has increased the exposure to digitalisation in education systems across OECD countries. The state of digital development of an education system also determines the sequencing and timing of different policies. An assessment of where countries stand in the digital transformation of their education systems and the challenges they face as digital technologies increasingly permeate learning processes can provide a first step in guiding the sequencing of policies necessary to enable successful digital education. Countries with high shares of

students lacking basic access to quality Internet connection or digital equipment for learning should begin by supporting investment in the provision of access to digital education technologies. Countries that have higher levels of basic access to digital technologies can put a stronger emphasis on steering innovation in digital education technologies, enhancing monitoring and evaluation of digital education to ensure the sustainability of its outcomes, and forward planning to adjust to evolving digital technology trends. Irrespective of education systems' starting point and their current state of digital exposure, Figure 1.2 provides a general checklist of policies to consider for enabling a more effective roll-out of digital education.

Digital education is influenced by a range of policies outside of the immediate realm of national education policy makers. These include national policies from other policy areas (e.g. innovation, labour market, social policies) as well as policies, regulations or guidelines regarding digital education passed at a supranational level (e.g. EU Council recommendations, European Commission guidelines). Given that digital education does not happen in isolation, the analytical framework highlights the links that need to be established between digital education policies and the wider policy realm.

Finally, the analytical framework acknowledges the role digital technologies themselves can play in supporting better policies for digital education. As data creation and collection expands with digital transformation, OECD countries can increasingly tap the potential of digital technologies and available data to enhance the design and implementation of their education policies. In education systems, data – including big data – can support teachers, education institution leaders and policy makers in improving the effectiveness of their practices and policies. Digital technologies and data can support better policy co-ordination and create more integrated public services, identify emerging trends more easily (e.g. in terms of new professional development needs) and help to monitor and evaluate the outcomes of education.

Levels of analysis

Each of the dimensions discussed in the previous section must include policies to target a range of actors within and outside education systems (e.g. capacity building efforts must address teachers as well as education institutions and local education authorities insofar as they are involved in implementing digital education policies). The analytical framework thus comprises different levels of analysis, covering the various actors and institutions which digital education policies can target. Within the report, these levels of analysis are treated in a cross-sectional manner where each chapter will consider, as far as possible, policies targeted at the relevant analytical levels. The levels considered in the report include:

1. **Students**: as the primary beneficiaries of digital education.
2. **Parents**: to the extent that parents can facilitate and shape student engagement with digital education technologies or raise students' awareness about digital education-related risks and protect them, particularly when digital education activities take place in hybrid or fully online formats
3. **Teaching staff**: as key actors engaged in the delivery of digital education.
4. **Education institutions, including their leadership teams**: as key facilitators of institutional change.
5. **Sub-central authorities**: Administrative authorities below the central level (including state-level, regional-level or local-level authorities) may be involved in the acquisition of digital education technologies or in providing support to education institutions.
6. **System-level authorities:** In many systems, central authorities or system-level agencies are responsible for providing overall strategic direction and guidance for the digital transformation of education. They may also be responsible for issuing regulations, designing curricula and providing funding for digital education.
7. **Broader digital education stakeholders**: The broader education stakeholders comprise a range of additional actors who shape digital education including education technology (EdTech)

developers, research institutions and teacher unions. These actors might be subject to government regulation and/or act as valuable partners in the implementation of policies for digital education.

Digital education outcomes

The use of digital education technologies is not an end in itself but should serve to advance the broader goals of education systems. If the right conditions are in place to enable their effective use, digital education technologies have the potential to enhance a number of important outcomes, both inside and outside of the classroom and help education systems in their pursuit of quality, equity and efficiency.

Types of outcomes

The analytical framework acknowledges that the use of digital education technologies affects a wide range of education and social outcomes. This includes students' cognitive skills and digital literacy, socio-emotional skills and well-being as well as broader labour market and social outcomes. Digital technologies can shape these outcomes either directly (e.g. personalised learning tools might enhance cognitive skills) or indirectly through positively influencing other factors that are relevant for learning outcomes (e.g. teacher workload).

Cognitive, digital and socio-emotional skills

Over the past years, the demand for skills has changed fundamentally. Digital skills and competencies have become crucial in labour markets and everyday lives (OECD, 2019[6]). Awareness of the importance of socio-emotional skills as strong predictors of well-being, education and labour market outcomes and the role of education in fostering these skills has also increased. Even within the domain of cognitive skills – which have conventionally formed the core of education provision – there have been considerable shifts as analytical thinking skills, problem solving skills and creative thinking skills increasingly overshadow traditional knowledge acquisition skills (World Economic Forum, 2020[17]; OECD, 2019[6]).

Digital tools can provide key avenues to foster these skills. For instance, there is clear evidence that the use of digital technologies in education can enhance students' digital skills (Malamud and Pop-Eleches, 2011[18]; Malamud et al., 2018[19]; Bulman and Fairlie, 2016[8]). At the same time, innovative education technologies such as gamification or AI-based learning have been identified as promising with respect to developing and assessing a range of cognitive and socio-emotional skills which have previously found little response in conventional curricula and pedagogies (MGIEP, 2020[20]; OECD, 2021[21]). However, previous analysis indicates that not all uses of digital technologies lead to positive learning outcomes, and promoting access to digital equipment alone is insufficient (Bulman and Fairlie, 2016[8]; OECD, 2019[6]; OECD, 2022[22]). Seizing the potential of digital technologies depends on how and with which pedagogical intent they are used in teaching and learning. In fact, evidence from OECD countries shows that a conducive digital education policy ecosystem can enable more effective and innovative uses of digital technologies for learning and teaching (OECD, 2022[22]).

Well-being and managing digital risks

Digital education must also be oriented to support students' well-being and the risks of harm associated with the use of digital technologies must be adequately managed. Inadequate uses of digital technologies, cyberbullying and risks to student privacy online are core concerns of education systems across OECD countries (Burns and Gottschalk, 2019[23]). These risks have been elevated by increased exposure to digital technologies throughout the COVID-19 pandemic. Although digital technologies enabled students to continue learning throughout the pandemic, increased screentime likely led to increases in some adverse effects on well-being, such as reduced sleep quality and symptoms of anxiety (UNICEF, 2021[24]). As the pandemic contributed to a long-lasting permeation of digital technologies in education systems, policy

makers need to find ways to protect learners from these risks and ensure their well-being in digital learning environments.

Educating students on responsible and safe usage of digital technologies thus becomes highly relevant to address the risks of digital technologies for student well-being. For instance, digital skills help children to cope better with cyberbullying (Gottschalk, 2022[25]). Students who have benefitted from digital education have also proven more able to tackle disinformation and distinguish fact from opinion (OECD, 2021[7]). In adulthood, high levels of literacy, numeracy and problem-solving skills in technology-rich environments increase the likelihood that adults take action to enhance their security online (e.g. by managing access to their personal information, using anti-tracking software or changing settings to limit cookies) (OECD, 2019[6]).

Labour market and social outcomes

Going beyond individual level outcomes, digital education is also crucial to realise broader economic and social outcomes. The wider economy is moving away from reliance on low-skilled routine tasks, towards technology-based non-routine labour. In addition to digital skills, these trends require a broad spectrum of cognitive and socio-emotional skills to adapt to a fast-moving professional environment (OECD, 2019[6]). Changing skill demands have not only widened wage inequalities over the past decades, if they go unmet, they might also stand in the way of economic growth and development. In fact, recent labour market analysis of job postings in a range of EU countries points at significant mismatches in supply and demand for digital skills (OECD, 2022[26]). Broadly advancing digital literacy and leveraging digital technologies to foster a wealth of cognitive and socio-emotional skills is thus essential to promote economic growth and inclusion in the long term.

By enhancing educational inclusion, digital education might also contribute to more favourable social outcomes for marginalised student groups such as children with special education needs (SEN) (US Department of Education, 2015[27]; Brussino, 2020[28]). More generally, new analytical tools and personalised learning technologies can enable educators to respond to each student's needs, adapt their teaching to different learning styles, abilities and interests, and provide additional support to students who might otherwise fall behind. Insofar as digital technologies can facilitate more inclusive education systems and reduce educational failure, they can unlock a range of desirable outcomes for those individuals that were previously denied the broad benefits from education including higher civic engagement, life satisfaction, physical and mental health (OECD, 2022[22]).

Outcome dimensions: Quality, access and equity, and efficiency

Most education and training systems seek to improve the outcomes discussed above along multiple dimensions: quality, access and equity, and efficiency. They seek to raise the overall quality of education, to promote equity in and through digital education, and to do so at the lowest possible cost. If enabling conditions are in place to support their effective use, digital education technologies have the potential to enhance the impact of teaching and learning along each of these dimensions 1) by enhancing the quality of teaching and students' learning experience, 2) by promoting access, equity and inclusion through personalised learning tools and assistive technologies, and 3) by making educators' work more efficient. In addition to describing the possibility frontier of digital education technologies, the following sections take stock of the empirical evidence for their beneficial impact. Overall, where evidence exists, it suggests that the presence of technology in and of itself is not a guarantee for improved teaching and learning and that what matters is how students and teachers make use of it (Fishman and Dede, 2016[29]).

Enhancing the quality of education

Observational data shows no consistent correlation between the use of digital education technology and higher student performance. Overall, data from the Programme for International Student Assessment

(PISA) suggest that 15-year-old students with both very high and very low levels of digital device use at school tend to display poorer performance in reading, science, mathematics (OECD, 2019[6]) and in collaborative problem solving (OECD, 2017[30]), whereas moderate engagement with digital technologies tends to be associated with better performance. In-depth studies of PISA data from New Zealand suggest that the use of digital devices in class may support learning in some cases while hindering it in others, particularly when it is not guided by teachers. Although the results varied slightly across the domains of reading, mathematics and science, PISA scores in New Zealand tended to be higher where teachers used digital devices (either alone or with their students). Conversely, students who used devices unaccompanied by the teacher (around 10% of them) had considerably lower performance in mathematics and science than students who used no devices in their lessons (Sutcliffe, 2021, p. 5[31]).

In recent years, evidence from experimental and quasi-experimental research that allow for causal inferences has somewhat improved our understanding of the impact of digital education technologies. It suggests, for example, that simple policy interventions in support of digitalisation – such as investments to increase students' access to devices like laptops or tablets – have little to no positive effects on their education outcomes (Bulman and Fairlie, 2016[8]; Minea-Pic, n.d.[32]). Instead, what appears to matter for student learning is which education technologies are used and how they are integrated into the learning process. Nevertheless, much remains to be understood about the mechanisms through which the use of digital education technologies affects student performance, as well as the extent to which the effects observed in case studies can be generalised to other contexts and interventions (Bulman and Fairlie, 2016[8]). Likewise, many applications at the frontier of education technology are still emerging and do not yet permit definitive conclusions about their scalability or their effectiveness when embedded in the teaching process.

One area in which digital education technologies have already demonstrated a positive impact are targeted interventions focused on computer assisted learning (CAL), i.e. computer programmes and other software applications designed specifically to improve academic skills, and technology-enabled behavioural interventions (Bulman and Fairlie, 2016[8]; Escueta et al., 2017[33]; Escueta et al., 2020[34]). In particular, personalised forms of CAL have been effective in advancing cognitive skill formation, especially in the areas of mathematics (Roschelle et al., 2016[35]; Murphy et al., 2020[36]), and shown promise to overcome common challenges in classrooms with a range of learning levels (Escueta et al., 2020[34]). Nevertheless, reviews underline that the quality of implementation is an important condition for the positive effects of CAL and that it is only successful to the extent that it helps educators to engage students in academic learning that matches their needs and abilities (Escueta et al., 2020, p. 984[34]).

The COVID-19 pandemic has also demonstrated the benefits of Learning Management Systems (LMS), which allowed teachers to manage their classes and organise learning resources for remote or hybrid instruction. LMS have also been used to assess student learning and facilitate peer-to-peer and educator-student communications through integrated video-conferencing functions or chat rooms (Khine and Saleh, 2010[37]). There is no internationally comparative data on the share of schools or universities that are equipped with LMS (Vincent-Lancrin, Cobo Romaní and Reimers, 2022[38]), but education systems such as Estonia, where the use of LMS and online learning materials was already well-established prior to the pandemic, have adapted to the new circumstances with greater ease (Gouëdard, Pont and Viennet, 2020, p. 24[39]).

In the VET sector, augmented and virtual reality-based instruction have been argued to hold promise for integrating on-the-job and off-the-job learning more tightly, allowing key concepts to be reinforced theoretically at the same time as students apply them practically in a work context (World Bank, 2021[40]). In some cases, these technologies are also safer and can be cheaper to implement by reducing the need for expensive physical equipment. or can help to develop occupational skills remotely (OECD, 2021[41]). Nevertheless, there is limited systematic information concerning the use of technologies in work-based learning, and their impact on skills acquisition and outcomes in the labour market is not yet clear.

Besides improving learning outcomes, the use of digital education technologies has been credited for its potential to enable a more engaging and enjoyable learning experience, to promote the development of non-cognitive skills, and to broaden students' horizons by letting them engage with people and ideas from across the world (OECD, 2020[4]). Others have expressed concerns about the impact that the increasing use of digital tools might have on children's emotional well-being, their mental health and brain development (OECD, 2017[42]). Some experimental studies have shown that specific technology-enabled behavioural interventions can help to improve the formation of non-cognitive skills for learners at various levels of education, although effects tend to be small (Escueta et al., 2020[34]). However, most studies do not observe the effect of technology use on non-cognitive outcomes in educational settings. Whilst some studies on the mental health outcomes of digital technologies show small negative effects, existing evidence on the topic is largely correlational and raises concerns of reverse causality (Gottschalk, 2019[43]). In general, the causal effects of technology use are difficult to establish since they tend to depend on the kinds of digital activities children may be engaging in (Burns and Gottschalk, 2019[23]).

In higher education, rigorous evidence of the effectiveness of digitalisation is relatively rare, partly since much of the early uptake of digitalisation was driven by individual instructors who had expertise in and enthusiasm for exploring digital technologies for their education delivery (Tømte et al., 2019[44]). As a result, many of the studies are observational and descriptive and there is limited rigorous research on the effectiveness of digital tools (Escueta et al., 2020[34]). Most research on the impact of digital education technology in higher education has focused on the efficacy of online or blended course delivery and there is some evidence to suggest that it can lead to improvements on a range of outcomes related to access, equity and educational quality. At least in one case, a randomised control trial also established efficiency gains, finding that university engineering courses delivered in blended formats or fully online provided similar learning outcomes as in-person courses at significantly lower cost (Chirikov et al., 2020[45]). On the whole, however, a large meta-analysis of experimental studies suggests that higher education courses delivered through blended learning had similar learning outcomes as traditional face-to-face courses, while wholly online courses had worse outcomes (Escueta et al., 2020[34]), and students with lower levels of academic ability are principally those whose learning gains are smallest.

Promoting equity, access and inclusion

Besides improving student performance, the use of digital education technologies holds promise as a means to overcome learning inequalities and to create more inclusive education systems and societies (ICF Consulting Services Ltd, 2015[5]). New analytical tools and personalised learning technologies could enable educators to be more responsive to each student's needs, adapt their teaching to different learning styles, abilities and interests and provide additional support to students who might otherwise fall behind. In addition, various types of assistive technologies have been designed to increase, maintain, or improve the functional capabilities of children with special education needs (SEN) and can allow them to take part in learning interactions from which they were previously excluded (US Department of Education, 2015[27]; Brussino, 2020[28]).

Examples of digital assistive technologies include specialised software that helps students with motor impairments to write by dictating text or wearables devices relying on AI that help students with visual impairments read books or recognise faces (Vincent-Lancrin and van der Vlies, 2020[46]). Digital forms of augmentative and alternative communication (AAC) can also be used to facilitate communication between students with SEN and their teachers or peers (UNESCO, 2011[47]; Light, McNaughton and Caron, 2019[48]), to support the development of autistic children's social skills (Good, 2021[49]; Porayska-Pomsta et al., 2018[50]), or to help children with Attention-Deficit/Hyperactivity Disorder (ADHD) follow classroom instruction (Mezzanotte, 2020[51]).

Technological advances have also facilitated the diagnosis of special education needs in a number of domains. For example, automated analyses of BHK tests (a widely used method to diagnose dysgraphia based on the Concise Assessment Scale for Children's Handwriting) have achieved levels of accuracy

similar to those of experts (Asselborn et al., 2018[52]). Other domains in which new types of analytical software have facilitated the diagnosis of special education needs include dyslexia, language development and functional writing skills (Good, 2021, p. 63[49]).

Higher education institutions (HEIs) have long faced difficulties in delivering to, assessing, and supporting disadvantaged students and those with special education needs (Hanafin et al., 2007[53]). Digital technologies offer HEIs an opportunity to implement a universal design for learning (UDL) approach, adapting to learners' needs by using multiple formats for presenting and transmitting information, engaging them and assessing their responses (CAST, nd[54]). Assistive technologies – ranging from universal design in instruction to accessible e-learning technology and voice-activated dictation software – also promise to widen access to higher education to students with disabilities (Seale, Wald and Draffan, 2008[55]; Asselin, 2014[56]).

Digital education technologies have also been used in targeted efforts to support other disadvantaged student groups. For example, digital language learning tools have been used to facilitate the integration of immigrant or refugee students by helping teachers to enrich and transform existing curricula, by serving as a cultural mediator for children of different ethnic and cultural backgrounds or as a communication and documentation tool (European Commission et al., 2021[57]). A number of HEIs in the United States have collaborated with foundations and EdTech firms to develop digital courseware to meet the needs of socio-economically disadvantaged students and those from historically underserved ethnic groups and provide training for professors and instructional staff (Lederman, 2022[58]).

Another way in which digital education technologies can promote equity and close learning gaps is by providing struggling students with additional support. Adaptive digital learning and assessment materials, for example, can support those who have fallen behind to catch up (Ganimian, Vegas and Hess, 2020[2]) and early warning systems can help educators to identify students at risk of failure in order to provide them with targeted support (Bowers, 2021, p. 187[59]). Although many early warning indicators remain highly inaccurate, some systems can predict dropout with an accuracy above 80-90% (Bowers, 2021[59]).

Finally, digital technologies can improve access to high-quality education for students who might otherwise be excluded. For example, it can help students to follow classroom activities from home (or elsewhere) when they cannot attend in person for an extended period of time, for example due to illness, accidents or care responsibilities (OECD, 2019[60]; UNESCO, 2011[47]). In rural and remote areas, different forms of e-learning – sometimes blended with traditional face-to-face delivery – can help to alleviate the disadvantages faced by students in areas that lack access to a rich educational offer (European Commission et al., 2021[57]). Countries like Chile, France and school districts in the United States have invested significantly in rural schools' digital infrastructure and the use of technology to provide rural students with access to additional learning opportunities (Sipple and Brent, 2015[61]; Echazarra and Radinger, 2019[62]). In higher education, digital consortia permit remote and weakly-resourced institutions to share courses with one another, permitting students to finish their study programmes by taking required classes online that are not offered by their own institution (Steele, 2022[63]).

Saving costs and increasing educators' efficiency

While investments in digital education technology can be expensive, analysts predict that they could bring about a range of efficiency gains. Not only could they help to detect school students at risk of failure and lead to faster completion times for students in higher education, they also promise to increase educators' efficiency in a number of domains. For example, technology can help teachers to devote more of their time to instruction by reducing the time that they spent on tasks such as correcting homework, administrative duties or routine communications with parents (Escueta et al., 2020[34]). A recent survey of more than 2 000 school teachers in Canada, Singapore, the United Kingdom and the United States suggests that between 20% and 40% of teachers' time is dedicated to activities that could be automated (OECD, 2019[64]; Bryant et al., 2020[65]). There is thus significant potential in some systems for digital technologies to save

educators' time (and potentially to reduce their levels of stress) by streamlining or automating repetitive and peripheral tasks (Selwood and Pilkington, 2005[66]; Ilkka, 2019[67]; OECD, 2021[68]).

Online platforms and communities also offer new ways for educators to access curriculum resources, to share ideas and materials and to exchange teaching practices with their peers. This could not only enrich their practice but also reduce the time they need to prepare lessons (OECD, 2021[68]; Lantz-Andersson, Lundin and Selwyn, 2018[69]). In addition, digital technologies can allow educators to reach a larger number of students beyond their own classroom using different forms of e-learning (ICF Consulting Services Ltd, 2015[5]). In some contexts, e.g. in remote areas or "hard-to-staff schools", standardised learning content and digital delivery have already allowed authorities to maintain education provision at scale despite a shortage of qualified educators or to lower cost without affecting learning outcomes (Ganimian, Vegas and Hess, 2020[2]; Chirikov et al., 2020[45]).

At the same time, the use of digital education technology can be perceived as a threat to instructional quality and teachers' professionalism. While digital technologies could empower teachers to exercise greater autonomy in designing their learning environments and to engage in more granular, individualised forms of assessment (Paniagua and Istance, 2018[70]), critics have warned that automation can also have the opposite effect, leading to more standardised forms of assessment and reducing teachers' work to the transmission of pre-fabricated learning materials. At the same time, not all tasks susceptible to automation are likely to be digitalised and – even where they are – it is expected that digital technologies will transform how teachers engage in their activities, rather than replace them (OECD, 2021[21]; OECD, 2021[68]). Particularly in higher education, the move to online or hybrid learning environments has also led to concerns about the role of intellectual property rights to recorded lectures and digital course materials, as well as the risks increased tracking poses for both students and faculty (CAUT, 2020[71]).

References

Asselborn, T. et al. (2018), "Automated human-level diagnosis of dysgraphia using a consumer tablet", *npj Digital Medicine*, Vol. 1/42, pp. 1-9, https://doi.org/10.1038/s41746-018-0049-x. [52]

Asselin, S. (2014), "Assistive technology in higher education", in Information Resources Management Association (ed.), *Assistive Technologies: Concepts, Methodologies, Tools, and Applications*, IGI Global, https://doi.org/10.4018/978-1-4666-4422-9.CH062. [56]

Bowers, A. (2021), "Early warning systems and indicators of dropping out of upper secondary school: the emerging role of digital technologies", in *OECD Digital Education Outlook 2021: Pushing the Frontiers with Artificial Intelligence, Blockchain and Robots*, OECD Publishing, Paris, https://doi.org/10.1787/c8e57e15-en. [59]

Brussino, O. (2020), "Mapping policy approaches and practices for the inclusion of students with special education needs", *OECD Education Working Papers*, No. 227, OECD Publishing, Paris, https://doi.org/10.1787/600fbad5-en. [28]

Bryant, J. et al. (2020), *Artificial Intelligence in Education: How Will it Impact K-12 Teachers*, McKinsey, https://www.mckinsey.com/industries/education/our-insights/how-artificial-intelligence-will-impact-k-12-teachers (accessed on 24 April 2022). [65]

Bulman, G. and R. Fairlie (2016), "Technology and Education: Computers, Software, and the Internet", *Handbook of the Economics of Education*, Vol. 5, pp. 239-280, https://doi.org/10.1016/B978-0-444-63459-7.00005-1. [8]

Burns, T. and F. Gottschalk (eds.) (2019), *Educating 21st Century Children: Emotional Well-being in the Digital Age*, Educational Research and Innovation, OECD Publishing, Paris, https://doi.org/10.1787/b7f33425-en. [23]

CAST (nd), *The UDL guidelines*, https://www.cast.org/?utm_source=udlguidelines&utm_medium=web&utm_campaign=none&utm_content=header (accessed on 27 May 2022). [54]

CAUT (2020), *Remote teaching: Privacy and intellectual property concerns*, Canadian Association of University Teachers (CAUT), https://www.caut.ca/sites/default/files/caut-briefing-note-remote-teaching-privacy-and-intellectual-property_2020-04.pdf (accessed on 6 May 2022). [71]

Cerna, L. et al. (2021), "Promoting inclusive education for diverse societies: A conceptual framework", *OECD Education Working Papers*, No. 260, OECD Publishing, Paris, https://doi.org/10.1787/94ab68c6-en. [16]

Chirikov, I. et al. (2020), "Online education platforms scale college STEM instruction with equivalent learning outcomes at lower cost", *Science Advances*, Vol. 6/15, https://doi.org/10.1126/sciadv.aay5324. [45]

Echazarra, A. and T. Radinger (2019), "Learning in rural schools: Insights from PISA, TALIS and the literature", *OECD Education Working Papers*, No. 196, OECD Publishing, Paris, https://doi.org/10.1787/8b1a5cb9-en. [62]

Escueta, M. et al. (2020), “Upgrading education with technology: Insights from experimental research”, *Journal of Economic Literature*, Vol. 58/4, pp. 897-996, https://doi.org/10.1257/jel.20191507. [34]

Escueta, M. et al. (2017), “Education Technology: An Evidence-Based Review”, *NBER Working Papers*, No. 23744, National Bureau of Economic Research, Cambridge, MA, http://www.nber.org/papers/w23744 (accessed on 6 April 2022). [33]

European Commission (n.d.), *DigCompOrg Framework*, https://joint-research-centre.ec.europa.eu/european-framework-digitally-competent-educational-organisations-digcomporg/digcomporg-framework_en (accessed on 20 February 2023). [13]

European Commission, M. et al. (2021), *Enhancing learning through digital tools and practices : how digital technology in compulsory education can help promote inclusion*, Publications Office of the European Union, Luxembourg, https://doi.org/10.2766/365846. [57]

Fishman, B. and C. Dede (2016), “Teaching and Technology: New Tools for New Times”, in Gitomer, D. and C. Bell (eds.), *Handbook of Research on Teaching*, American Educational Research Association, Washington, DC, https://doi.org/10.3102/978-0-935302-48-6_21. [29]

Ganimian, A., E. Vegas and F. Hess (2020), *Realizing the Promise: How Can Education Technology Improve Learning for All?*, The Brookings Institution, Washington, https://www.brookings.edu/wp-content/uploads/2020/08/edtech_playbook_full_v2.pdf (accessed on 6 April 2022). [2]

Good, J. (2021), “Serving students with special needs better: How digital technology can help”, in *OECD Digital Education Outlook 2021: Pushing the Frontiers with Artificial Intelligence, Blockchain and Robots*, OECD Publishing, Paris, https://doi.org/10.1787/40fa80d3-en. [49]

Gottschalk, F. (2022), “Cyberbullying: An overview of research and policy in OECD countries”, *OECD Education Working Papers*, No. 270, OECD Publishing, Paris, https://doi.org/10.1787/f60b492b-en. [25]

Gottschalk, F. (2019), “Impacts of technology use on children: Exploring literature on the brain, cognition and well-being”, *OECD Education Working Papers*, No. 195, OECD Publishing, Paris, https://doi.org/10.1787/8296464e-en. [43]

Gouëdard, P., B. Pont and R. Viennet (2020), “Education responses to COVID-19: Implementing a way forward”, *OECD Education Working Papers*, No. 224, OECD Publishing, Paris, https://doi.org/10.1787/8e95f977-en. [39]

Hanafin, J. et al. (2007), *Including young people with disabilities: Assessment challenges in higher education*, DOI 10.1007/s10734-006-9005-9. [53]

ICF Consulting Services Ltd (2015), *Literature Review on the Impact of Digital Technology on Learning and Teaching*, Scottish Government, Edinburgh, https://www.gov.scot/publications/literature-review-impact-digital-technology-learning-teaching/documents/ (accessed on 7 April 2022). [5]

IDB and HolonIQ (2021), *Education Technology in Latin America and the Caribbean*, https://publications.iadb.org/publications/english/document/Education-Technology-in-Latin-America-and-the-Caribbean.pdf (accessed on 12 April 2022). [1]

Ilkka, T. (2019), *The impact of Artificial Intelligence on learning, teaching, and education*, European Commission, Joint Research Centre, https://data.europa.eu/doi/10.2760/12297 (accessed on 24 April 2022). [67]

Khine, M. and I. Saleh (2010), *(eds) New science of learning. Cognition, computers and collaboration in education*, Springer, https://doi.org/10.1007/978-1-4419-5716-0. [37]

Lantz-Andersson, A., M. Lundin and N. Selwyn (2018), "Twenty years of online teacher communities: A systematic review of formally-organized and informally-developed professional learning groups", *Teaching and Teacher Education*, Vol. 75, pp. 302-315, https://doi.org/10.1016/J.TATE.2018.07.008. [69]

Lederman, D. (2022), *Courseware designed to close equity gaps*, https://www.insidehighered.com/news/2022/04/13/building-courseware-close-racial-gaps-gateway-classes. [58]

Light, J., D. McNaughton and J. Caron (2019), "New and emerging AAC technology supports for children with complex communication needs and their communication partners: State of the science and future research directions", *Augmentative and Alternative Communication*, Vol. 35/1, pp. 26-41, https://doi.org/10.1080/07434618.2018.1557251. [48]

Malamud, O. et al. (2018), *Do Children Benefit from Internet Access? Experimental Evidence from Peru*, National Bureau of Economic Research, Cambridge, MA, https://doi.org/10.3386/w25312. [19]

Malamud, O. and C. Pop-Eleches (2011), "Home computer use and the development of human capital", *The Quarterly Journal of Economics*, Vol. 126/2, pp. 987-1027, https://doi.org/10.1093/qje/qjr008. [18]

Mezzanotte, C. (2020), "Policy approaches and practices for the inclusion of students with attention-deficit hyperactivity disorder (ADHD)", *OECD Education Working Papers*, No. 238, OECD Publishing, Paris, https://doi.org/10.1787/49af95e0-en. [51]

Minea-Pic, A. (n.d.), "ICT resources in school education: What do we know from OECD work? [working title, forthcoming]", *OECD Education Working Papers*, OECD Publishing, Paris. [32]

Murphy, R. et al. (2020), "Investigating efficacy, moderators and mediators for an online mathematics homework intervention", *Journal of Research on Educational Effectiveness*, Vol. 13/2, pp. 235-270, https://doi.org/10.1080/19345747.2019.1710885. [36]

OECD (2023), *Is Education Losing the Race with Technology?: AI's Progress in Maths and Reading*, Educational Research and Innovation, OECD Publishing, Paris, https://doi.org/10.1787/73105f99-en. [9]

OECD (2022), *Skills for the Digital Transition: Assessing Recent Trends Using Big Data*, OECD Publishing, Paris, https://doi.org/10.1787/38c36777-en. [26]

OECD (2022), *Value for Money in School Education: Smart Investments, Quality Outcomes, Equal Opportunities*, OECD Publishing, Paris, https://doi.org/10.1787/f6de8710-en. [22]

OECD (2021), *21st-Century Readers: Developing Literacy Skills in a Digital World*, PISA, OECD Publishing, Paris, https://doi.org/10.1787/a83d84cb-en. [7]

OECD (2021), "Making the most of teachers' time", *OECD Education Policy Perspectives*, No. 29, OECD Publishing, Paris, https://doi.org/10.1787/d005c027-en. [68]

OECD (2021), *OECD Digital Education Outlook 2021 : Pushing the Frontiers with Artificial Intelligence, Blockchain and Robots | OECD Digital Education Outlook | OECD iLibrary*, https://doi.org/10.1787/589b283f-en (accessed on 1 February 2023). [10]

OECD (2021), *OECD Digital Education Outlook 2021: Pushing the Frontiers with Artificial Intelligence, Blockchain and Robots*, OECD Publishing, Paris, https://doi.org/10.1787/589b283f-en. [21]

OECD (2021), *Teachers and Leaders in Vocational Education and Training*, OECD Reviews of Vocational Education and Training, OECD Publishing, Paris, https://doi.org/10.1787/59d4fbb1-en. [41]

OECD (2020), *Back to the Future of Education: Four OECD Scenarios for Schooling*, Educational Research and Innovation, OECD Publishing, Paris, https://doi.org/10.1787/178ef527-en. [11]

OECD (2020), *PISA 2018 Results (Volume VI): Are Students Ready to Thrive in an Interconnected World?*, OECD Publishing, Paris. [4]

OECD (2019), *OECD Skills Outlook 2019: Thriving in a Digital World*, OECD Publishing, Paris, https://doi.org/10.1787/df80bc12-en. [6]

OECD (2019), *PISA 2021 ICT Framework*, https://www.oecd.org/pisa/sitedocument/PISA-2021-ICT-Framework.pdf (accessed on 8 April 2022). [60]

OECD (2019), *TALIS 2018 Results (Volume I): Teachers and School Leaders as Lifelong Learners*, TALIS, OECD Publishing, Paris, https://doi.org/10.1787/1d0bc92a-en. [64]

OECD (2017), *PISA 2015 Results (Volume III): Students' Well-Being*, PISA, OECD Publishing, Paris, https://doi.org/10.1787/9789264273856-en. [42]

OECD (2017), *PISA 2015 Results (Volume V): Collaborative Problem Solving*, PISA, OECD Publishing, Paris, https://doi.org/10.1787/9789264285521-en. [30]

OECD (2013), "OECD Review of Policies to Improve the Effectiveness of Resource Use in Schools (Design and Implementation Plan for the Review)" September, https://www.oecd.org/education/school/School-Resources-Review-Design-and-Implementation-Plan.pdf (accessed on 20 Jun 2023). [15]

Paniagua, A. and D. Istance (2018), *Teachers as Designers of Learning Environments: The Importance of Innovative Pedagogies*, Educational Research and Innovation, OECD Publishing, Paris, https://doi.org/10.1787/9789264085374-en. [70]

Porayska-Pomsta, K. et al. (2018), "Blending human and artificial intelligence to support autistic children's social communication skills", *ACM Transactions on Computer-Human Interaction (TOCHI)*, Vol. 25/6, https://doi.org/10.1145/3271484. [50]

Redecker, C., Y. Punie and European Commission. Joint Research Centre. (2017), "European Framework for the Digital Competence of Educators: DigCompEdu", https://doi.org/10.2760/178382. [14]

Røe, Y., S. Wojniusz and A. Bjerke (2022), "The digital transformation of higher education teaching: Four pedagogical prescriptions to move active learning pedagogy forward", *Frontiers in Education*, Vol. 6, p. 583, https://doi.org/10.3389/FEDUC.2021.784701. [3]

Roschelle, J. et al. (2016), "Online mathematics homework increases student achievement", *AERA Open*, Vol. 2/4, https://doi.org/10.1177/2332858416673968. [35]

Seale, J., M. Wald and E. Draffan (2008), *Exploring the technology experiences of disabled learners in higher education: challenges for the use and development of participatory research methods*, https://doi.org/10.1108/17549450200800. [55]

Selwood, I. and R. Pilkington (2005), "Teacher workload: Using ICT to release time to teach", *Educational Review*, Vol. 57/2, pp. 163-174, https://doi.org/10.1080/0013191042000308341. [66]

Singh, N. and A. Duraiappah (eds.) (2020), *Rethinking Learning: A review of social and emotional learning for education systems*, https://d1c337161ud3pr.cloudfront.net/files%2Fc1178d56-5c72-460b-bd58-02bfba9a6abd_RL_Rethinking%20Learning%20-%20A%20Review%20of%20Social%20and%20Emotional%20Learning%20For%20Education%20System.pdf (accessed on 1 February 2023). [20]

Sipple, J. and B. Brent (2015), "Challenges and strategies associated with rural school settings", in Ladd, H. and E. Fiske (eds.), *Handbook of Research in Education Finance and Policy*, Routledge, New York City, NY. [61]

Steele, D. (2022), *Joining forces to share courses: HBCUs are forming collectives to share courses across their campuses and create more paths to graduation*, https://www.insidehighered.com/news/2022/05/10/more-course-sharing-partnerships-help-students-graduate (accessed on 27 July 2022). [63]

Sutcliffe, R. (2021), *PISA 2018: Digital Devices and Student Outcomes in New Zealand Schools*, New Zealand Ministry of Education, Wellington, https://www.educationcounts.govt.nz/publications/schooling/pisa-2018-digital-devices-and-student-outcomes (accessed on 22 June 2022). [31]

Tømte, C. et al. (2019), *Digitalisation in higher education: mapping institutional approaches for teaching and learning*, DOI: 10.1080/13538322.2019.1603611. [44]

UNESCO (2011), *ICTs in Education For People with Disabilities: Review of Innovative Practice*, UNESCO Institute for Information Technologies in Education, Moscow, https://unesdoc.unesco.org/ark:/48223/pf0000193655 (accessed on 24 April 2022). [47]

UNICEF (2021), *Growing concern for well-being of children and young people amid soaring screen time*, https://www.unicef.org/press-releases/growing-concern-well-being-children-and-young-people-amid-soaring-screen-time (accessed on 25 May 2023). [24]

US Department of Education (2015), *Individuals with Disabilities Education Act (IDEA)*, https://sites.ed.gov/idea/ (accessed on 7 April 2022). [27]

Vincent-Lancrin, S., C. Cobo Romaní and F. Reimers (eds.) (2022), *How Learning Continued during the COVID-19 Pandemic: Global Lessons from Initiatives to Support Learners and Teachers*, OECD Publishing, Paris, https://doi.org/10.1787/bbeca162-en. [38]

Vincent-Lancrin, S. and R. van der Vlies (2020), "Trustworthy artificial intelligence (AI) in education: Promises and challenges", *OECD Education Working Papers*, No. 218, OECD Publishing, Paris, https://doi.org/10.1787/a6c90fa9-en. [46]

Vuorikari, R. et al. (2022), "DigComp 2.2: The Digital Competence Framework for Citizens - With new examples of knowledge, skills and attitudes", https://doi.org/10.2760/115376. [12]

World Bank (2021), *Unleashing the Power of Educational Technology in TVET Systems*, https://thedocs.worldbank.org/en/doc/61714f214ed04bcd6e9623ad0e215897-0400012021/related/EdTech-Report-FIN2-web.pdf (accessed on 25 April 2022). [40]

World Economic Forum (2020), *What are the top 10 job skills for the future?*, https://www.weforum.org/agenda/2020/10/top-10-work-skills-of-tomorrow-how-long-it-takes-to-learn-them/ (accessed on 1 February 2023). [17]

Annex 1.A. Definition of key terms

This annex defines some of the key terms referred to in the analytical framework and throughout the report.

Digital education

The term “digital education” encompasses all forms of teaching and learning enhanced by the use of digital technologies – whether fully online (both synchronous and asynchronous), hybrid, or blended teaching and learning activities:

- *Online education*. In this type of education, all instruction is delivered online, either synchronously or asynchronously, or a combination of both. While instruction is delivered at a distance, learners may have an opportunity to meet in person with peers or instructors, or to make use of on-campus facilities and learning materials. It is different from “distance education”, which is the term used to describe all technologies in which learner and instructor are physically separated.
- *Hybrid education*. This type of education relies on mix of online and face-to-face instruction, with the online components taking place synchronously, asynchronously, or as a combination of both. In contrast to blended education, hybrid education uses online instruction to replace and thus reduce the frequency of in-person instruction.
- *Blended education*. In this type of education, instruction takes place fully in-person and is blended with and complemented by online materials and activities. In blended courses, instruction may make use of a virtual learning environment (VLE) / learning management system (LMS), online open educational resources (OER), digital adaptive learning software, simulations, or gaming.

A range of digital tools, software, and learning resources can be used for education provided through all modes of delivery. The focus of this report is on digital technologies used by educators and students in the process of teaching and learning, rather than the other functions for which digital technologies are used by educational institutions (e.g. operational and business processes, resource management, and research activity).

Digital education technologies

Digital technologies, as defined in this document, include:

- networking including on-site networking (wired and wireless, staff, students, and public) and long-haul and off-site networking, including telecommunication services;
- on-premises server hardware and audio-visual equipment;
- end-user devices, including general-purpose hardware devices for staff and students, such as PCs, Macs, tablets and smartphones;
- application software and, in particular, educational software;
- data and data centres;
- cloud services;
- capability services such as technical support.

Throughout the report the terms “digital technologies” and “digital infrastructure” are used interchangeably.

Notes

[1] The digital infrastructure for research in higher education (including e.g. tools like text analytics systems, statistical packages, library and bibliometric packages, online access to journals, survey platforms, bibliographic databases and reference management tools) is not considered separately in the analysis.