Shaping Digital Education

ENABLING FACTORS FOR QUALITY, EQUITY AND EFFICIENCY

OECD

Shaping Digital Education

ENABLING FACTORS FOR QUALITY, EQUITY AND EFFICIENCY

BETTER POLICIES FOR BETTER LIVES

This document was produced with the financial assistance of the European Union. The views expressed herein can in no way be taken to reflect the official opinion of the European Union.

This document, as well as any data and map included herein, are without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

The statistical data for Israel are supplied by and under the responsibility of the relevant Israeli authorities. The use of such data by the OECD is without prejudice to the status of the Golan Heights, East Jerusalem and Israeli settlements in the West Bank under the terms of international law.

Note by the Republic of Türkiye
The information in this document with reference to "Cyprus" relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Türkiye recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Türkiye shall preserve its position concerning the "Cyprus issue".

Note by all the European Union Member States of the OECD and the European Union
The Republic of Cyprus is recognised by all members of the United Nations with the exception of Türkiye. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.

Please cite this publication as:
OECD (2023), *Shaping Digital Education: Enabling Factors for Quality, Equity and Efficiency*, OECD Publishing, Paris, https://doi.org/10.1787/bac4dc9f-en.

ISBN 978-92-64-84671-5 (print)
ISBN 978-92-64-75823-0 (pdf)
ISBN 978-92-64-70591-3 (HTML)
ISBN 978-92-64-84523-7 (epub)

Photo credits: Cover © Ground Picture/Shutterstock.com.

Corrigenda to OECD publications may be found on line at: www.oecd.org/about/publishing/corrigenda.htm.

Foreword

There is no question that digital technologies have profoundly transformed our lives over recent decades. Education is no exception with digital technologies having increasingly permeated schools and higher education institutions. The COVID-19 pandemic accelerated the digital transformation in education and led to an unprecedented increase in the use of digital education technologies, which have now become a key resource for OECD education and training systems. If used effectively, these technologies promise to transform teaching and learning practices and enhance educators' ability to provide high-quality instruction, to reduce learning inequalities through more differentiated learning approaches, and to create more inclusive and efficient education systems. In schools and higher education institutions, many expect that digital tools are here to stay and that their role in teaching and learning will continue to grow.

However, there is a broad consensus that the use of digital education technologies should not be an end in itself but serve the broader goals of education systems. This report thus 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: 1) by enhancing the quality of teaching and students' learning experience; 2) by promoting equity, access and inclusion through personalised learning tools and assistive technologies; and 3) by saving costs and making educators' work more efficient.

While the experience of the past few years has given us a glimpse of the potential of digital education technologies, the COVID-19 pandemic also exposed shortcomings in the extent to which digital technologies are currently enabling high-quality teaching and learning and underlined the need for supportive policies and conditions to make use of their potential. These experiences have also exposed the reality that many education systems are far from providing equitable access to high-quality digital technologies and cast light on some of the risks associated with their unregulated use. These developments raise the question of how education systems can harness the full potential of digital education, while mitigating associated risks.

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, and to guide governments in shaping the development of digital education.

Offering a range of perspectives for governments and education stakeholders, this report provides a comprehensive review of current trends and emerging policies, covering school education, vocational education and training (VET) and higher education. It also analyses enabling factors that can support quality, equity and efficiency in the use of digital technologies in education systems, taking stock of what we know about digital education policies and investigating promising international practices. It aims to support education systems 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 is on providing guidance to policy makers about how to optimise the use of digital technologies in the short- and medium-term.

However, the analytical framework proposed in the report also takes a longer-term perspective, recognising recent developments related to the rapidly improving capabilities of Artificial Intelligence (AI). These developments bring new focus to the role of education policy in regulating the use of AI in schools and higher education institutions, as well as in preparing learners for an AI-driven future. Whilst other OECD projects are investigating frontier uses of digital technologies and their eventual impact on education systems, this report is primarily concerned with the immediate policy implications of digital technologies within the existing institutional arrangements of OECD and European Union (EU) education systems. The report also acknowledges that, in the longer term, education systems might undergo more transformational changes in terms of the spaces and formats in which learning takes place, the education actors involved and the human resources policies in place. The analytical framework presented in this report nevertheless provides a solid basis for education systems to examine their digital education strategies and policies, and work together on developing a more coherent and effective policy ecosystem for digital education, including through the OECD project on Resourcing School Education for the Digital Age: Effective Digitalisation and Future-Ready Teachers.

This report has benefitted from generous financial support from the European Commission. It was prepared within the context of a joint European Commission-OECD project on the Enabling Factors of Digital Education and Skills (EFDES), which provided analytical support and research-based evidence to the European Commission to inform a Commission proposal for a Council Recommendation on the key enabling factors for successful digital education and training. The proposal was adopted by the European Commission on 18 April 2023 alongside a proposal for a Council Recommendation on improving the provision of digital skills in education and training. The two recommendations aim to support EU Member States and the education and training sector in providing high-quality, inclusive and accessible digital education and training and in developing the digital skills of European citizens. This report benefitted from inputs from officials of the Digital Education Unit within the European Commission's Directorate-General for Education, Youth, Sport and Culture (DG EAC), including Georgi Dimitrov, Ivana Juraga, Dimitra Rapti and Reinier Van der Weele. The OECD team would like to thank them for their invaluable feedback, suggestions and contributions to the report and gratefully acknowledge the financial support provided by the European Commission.

Within the OECD Directorate for Education and Skills, the preparation of this report was a collaborative effort between the teams for Resourcing School Education for the Digital Age and Higher Education Policy, both part of the Policy Advice and Implementation Division under the leadership of Paulo Santiago. The development of this report was guided by Karine Tremblay (Senior Analyst, Resourcing School Education for the Digital Age) with support from Thomas Weko and Simon Roy (Senior Analysts, Higher Education Policy, respectively until December 2022 and since January 2023). The analytical framework underpinning the report was developed by Andreea Minea-Pic (Analyst, Resourcing School Education for the Digital Age), under the guidance of Karine Tremblay, and with contributions from Luka Boeskens and Katharina Meyer (respectively, Analyst and Young Associate, Resourcing School Education for the Digital Age). Karine Tremblay and Gillian Golden (Analyst, Higher Education Policy) provided extensive comments for all chapters. The various chapters were co-authored as follows:

- Chapter 1: Luka Boeskens, Katharina Meyer and Andreea Minea-Pic.
- Chapter 2: Katharina Meyer and Andreea Minea-Pic.
- Chapter 3: Luka Boeskens and Roger Smyth (Higher Education consultant).
- Chapter 4: Andreea Minea-Pic, Ana Moreno-Monroy (Analyst, Higher Education Policy) and François Staring (Analyst, Higher Education Policy), with contributions from Gillian Golden.

- Chapter 5: Andreea Minea-Pic and Simon Roy, with contributions from Katharina Meyer, Ana Moreno-Monroy and Karine Tremblay.
- Chapter 6: Andreea Minea-Pic and Ana Moreno-Monroy.
- Chapter 7: Luka Boeskens and Thomas Weko, with contributions from Andreea Minea-Pic.
- Chapter 8: Luka Boeskens, Andreea Minea-Pic and Thomas Weko, with contributions from Katharina Meyer.
- Chapter 9: Gillian Golden and Karine Tremblay, with contributions from Andreea Minea-Pic and Katharina Meyer.

The authors acknowledge and express their gratitude to colleagues from the Directorate for Education and Skills for their valuable input and advice at different stages of the report's production. In particular, the report benefitted from the feedback and suggestions of the members of the Digitalisation Cluster of the Directorate for Education and Skills at the OECD, and in particular from Lucie Cerna, Francesca Gottschalk, Stéphanie Jamet, Cecilia Mezzanote, Mario Piacentini and Stéphan Vincent-Lancrin. Marika Prince co-ordinated the report production and administrative aspects, with support from Daiana Torres Lima, Katharina Meyer and Rachel Linden for report production, editing and communications, alongside Gillian Golden, Katharina Meyer and Andreea Minea-Pic in the editorial process.

The team would also like to thank Andreas Schleicher (Director of Education and Skills) and Paulo Santiago (Head of Division, Policy Advice and Implementation) for their overall guidance and support for the project, and feedback on the report draft.

Last, but not least, the authors also express their gratitude to delegates from the OECD Group of National Experts on School Resources, the OECD Group of National Experts on Higher Education and the Education Policy Committee for their comments on and inputs to this report. They have provided valuable policy examples and analytical guidance to its preparation, alongside representatives from Business at OECD (BIAC) and the Trade Union Advisory Committee to the OECD (TUAC) who had the opportunity to comment on drafts of this report.

Table of contents

FIGURES

TABLES

Abbreviations and acronyms

AAC	Augmentative and Alternative Communication
ADHD	Attention-Deficit/Hyperactivity Disorder
AI	Artificial Intelligence
AR	Augmented Reality
BHK	Concise Assessment Method for Children's Handwriting
BRNE	Banques de Ressources Numériques pour l'Ecole (Banks of digital education resources)
BYOD	Bring Your Own Device
CAL	Computer Assisted Learning
CEPS	Centre for European Policy Studies
CERI	OECD Centre for Education Research and Innovation
CPL	Continuing Professional Learning
DEQAR	European Database of External Quality Assurance Reports from higher education institutions
DESI	Digital Economy and Society Index
DL	Distance Learning
EC	European Commission
EdTech	Educational Technology
EHIS	Estonian Education Information System
EMS	Education Monitoring System
ENQA	European Network for Quality Assurance Agencies in the European Higher Education Area
ESG	European Standards and Guidelines for Quality Assurance in the European Higher Education Area
ESSIE	European Surveys of Schools: ICT in Education
ETRI	World Bank Edtech Readiness Index
GDPR	General Data Protection Regulation
HEI	Higher Education Institution
ICILS	International Computer and Information Literacy Study
ICO	Information Commissioner's Office
ICT	Information and Communication Technology
INQAAHE	International Network of Quality Assurance Agencies in Higher Education
INDEx	Irish National Digital Experience Survey
IPEDS	Integrated Post-Secondary Education Data System
ISCED	International Standard Classification of Education
IT	Information Technology
ITE	Initial Teacher Education
LMS	Learning Management System
MOOC	Massive Open Online Courses
NREN	National Research and Education Networks
PIAC	Programme for the International Assessment of Adult Competencies
PILA	Platform for Innovative Learning Assessment
PIRLS	Progress in International Reading Literacy Study
PISA	Programme for International Student Assessment
PPP	Public Private Partnership
R&D	Research and Development
SELFIE	Self-reflection on Effective Learning by Fostering the use of Innovative Educational technologies tool
SEN	Special Education Needs
SME	Small and Medium-sized Enterprises

TALIS	Teaching And Learning International Survey
TIMMS	Trends in International Mathematics and Science Study
UDL	Universal Design for Learning
VET	Vocational Education and Training
VLE	Virtual Learning Environments
VPN	Virtual Private Networks
VR	Virtual Reality

Executive summary

Digital technologies are a key resource for OECD education and training systems. If used effectively, they promise to transform teaching and learning practices and help to advance quality, equity and efficiency. Digital education technologies can enhance educators' ability to respond to students' learning needs and interests, to make teaching more engaging and differentiated, and to widen access to countless learning resources. New technologies also promise to extend the reach of highly effective educators, to reduce learning inequalities and to create more inclusive education systems.

Investment in education technology has surged worldwide over the past decade and digital education technologies increasingly permeate schools and classrooms. Since the COVID-19 pandemic, there has been an unprecedented increase in their use, which enabled the continuation of organised instruction during the crisis. In higher education, surveys show that most students, educators, and administrators expect higher education providers to continue widely using blended and hybrid learning in the future.

These developments raise the question of how education systems can make effective use of digital technologies and reap their potential. As it stands, most education systems are far from providing full and equitable access to high-quality digital technologies and their current use tends to fall short of transforming teaching and learning. The COVID-19 pandemic exposed these shortcomings and underlined the need for supportive policies and conditions to make use of the full potential of digital technologies in education.

This report seeks to support governments in shaping digital education by analysing digitalisation policies and enabling factors that can support quality, equity and efficiency. The report covers school education at the primary and secondary level, vocational education and training (VET) (including initial school-based VET), and higher education offered by education institutions. Digital technologies are broadly defined to include networks (such as the Internet), hardware, software and technology-related services. The report focuses on their uses in the context of teaching and learning.

Chapter 1 of the report presents an analytical framework to assess digital education policies along with eight analytical dimensions, which are then examined in more detail in subsequent chapters, taking stock of challenges and opportunities for policymakers, empirical evidence, and policy practices in OECD education systems:

- Chapter 2 - Strategic visions and policy co-ordination
- Chapter 3 - Pedagogical approaches, curricula and assessments
- Chapter 4 - Guidance and regulatory frameworks
- Chapter 5 - Funding and procurement
- Chapter 6 - Accessible, innovative and high-quality digital infrastructure
- Chapter 7 - Capacity building
- Chapter 8 - Human resource policies
- Chapter 9 - Monitoring and evaluation

For each dimension, the report also presents a number of promising policies and initiatives that may help education systems to unlock the potential of digital education technologies. Some of the key policy directions emerging from the analysis are summarised below.

Developing a holistic strategic vision to coordinate digital education policy

A coherent and forward-looking strategy is critical to guide the development and successful implementation of digital education policy. Such strategies should be guided by a forward-looking vision for digital education and consider the wider policy ecosystem beyond education. They should also consider the implications of emerging technologies and be continuously updated to reflect changes in the digital landscape. In increasingly digitalised education systems, a digital education strategy that is adapted to the system's governance arrangements can facilitate co-ordination and alignment among stakeholders to improve the development and implementation of policies.

Ensuring that digital technologies are used to promote quality and equity in education

The use of digital education technologies is not an end in itself. Their development, selection and uses in the classroom should be guided by their impact on learners and the overriding goal of promoting quality and equity in education. Making effective use of digital technologies for high-quality education requires the adaptation of pedagogical approaches, curricula and assessments. It also requires careful monitoring and evaluation to measure the impact of digital education policies and to build evidence on the effective use of education technologies. Furthermore, educators need to be supported to make informed decisions on the selection and use of digital tools in the classroom, which may require the adaptation of human resource policies. Public authorities can support this process through guidance, regulatory frameworks, quality assurance policies and by promoting peer-learning on good practices across the system.

Aligning funding models and enabling smart investments in education technology

Promoting equity starts by addressing inequalities in access to innovative and high-quality digital infrastructure and directing scarce resources to where they are most needed. Yet, policy makers in many education systems have limited information on which to base their investment decisions, and the funding environment for digital education technologies is fragmented, creating planning and budgeting difficulties for education institutions. Education systems have developed several promising approaches to address these challenges by adapting funding and revenue models to the specificities of digital education and by building collective capacity across education institutions to make smart investments in digital technologies. Governments should seek to further align funding models with policy objectives, ensure transparency in procurement processes, and promote collaboration across sectors to boost investment and innovation in education technologies.

Building capacity for digital education at all levels of the education system

To make effective use of digital education technologies, it is essential to build digital capacity at all levels of the education system, among educators and institution leaders, but also students, parents and administrators. Public authorities should support education institutions in selecting the right digital tools to meet their needs, facilitate their interactions with innovative education technology solutions and empower leadership teams to build a culture of digital education in schools and higher education institutions.

Strengthening capacity among local authorities and within the wider education ecosystem can further support the successful implementation of digital education policies. Most importantly, supporting educators, promoting peer-learning and offering continuing professional learning opportunities will be critical to ensure that digital education technologies are used to advance quality and equity in education.

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

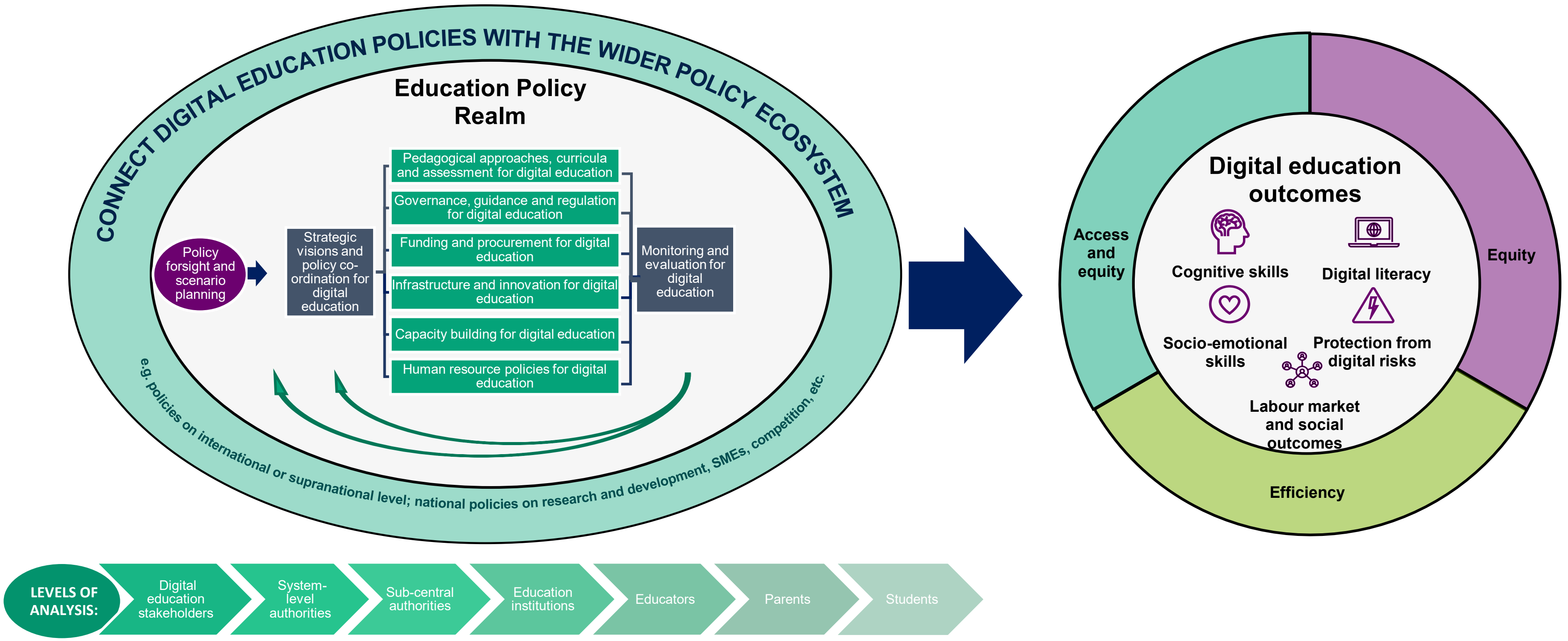
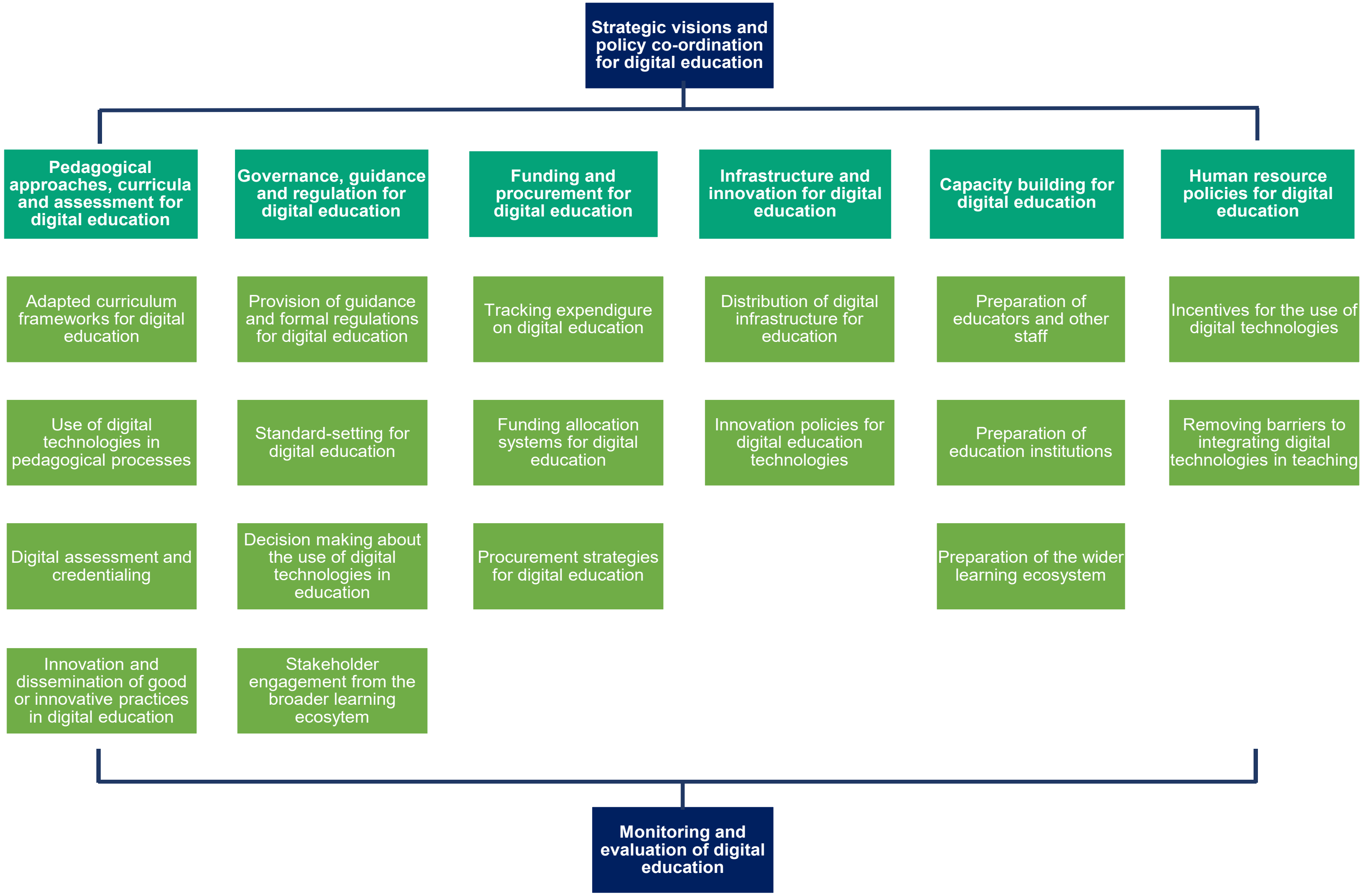


Figure 1.2. Analytical framework for a digital education policy ecosystem: Analytical dimensions and policy levers



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.

2 Strategic visions and policy co-ordination for digital education

This chapter presents some of the recent developments and emerging challenges that policy makers and education institutions have to consider when developing their strategic vision and pursuing policy co-ordination related to digital education. The analysis highlights promising approaches for improving strategic development, co-ordination, alignment, and adaptability of policies within increasingly digitalised education systems. In particular, it recommends that governments should recognise the benefits of a coherent digital education strategy, which is aligned to the wider policy ecosystem, and which takes account of the specific governance arrangements within education systems. Digital education strategies and policies should also maintain a future-oriented focus, considering the implications of emerging technologies.

Introduction

This chapter provides context for the more specific policy levers discussed in the following chapters by underlining the importance of a strategic vision that encompasses all aspects of digital education. A strategic vision must clearly set out goals for digital education and link them to concrete policy measures across the policy areas discussed in the report – such as infrastructure, regulation or capacity building for digital education - whilst providing concrete provisions for the monitoring and evaluation of these policies.

However, having a strategic vision for digital education alone is not enough to guarantee that good intentions turn into desired changes in practice. A strategic vision is most likely to lead to success in implementing policy reform if it is well-communicated and coupled with time-bound action plans and appropriate funding arrangements.

It is equally critical to pay attention to policy co-ordination. Policies for digital education should not be developed in silos. Policies both within and outside the realm of education have tangible effects on the implementation of digital education strategies. For example, existing policies for regional development, regulations for the technology sector or teacher professional development policies may all interact with digital education policies. Thus, a strategic vision for digital education should be aligned with the wider policy ecosystem to ensure coherency across policy fields. Policy co-ordination should ensure that the wider policy ecosystem sends consistent signals to the system actors and the various policies mutually reinforce each other in steering behaviours.

Strategic policies for digital education also need to be adapted to the governance arrangements within which they function. In this context, a strategic vision for digital education as well as related implementation plans should serve to delineate responsibilities for implementation among different levels of government, education institutions and other relevant stakeholders and encourage co-operation among them to achieve the desired vision and goals.

While a strategic vision for digital education should provide medium- to long-term guidance on the direction of policy reform, flexibility and responsiveness is critical in the rapidly evolving field of digital education. Strategic documents for digital education thus need to be flexible enough to adapt to societal, technological or economic changes, and to integrate new policies as they are developed. This can be guaranteed by designing purposeful feedback loops to identify and adapt to emerging needs, constraints or challenges, implementation issues or undesired effects.

Currently, countries face a range of challenges in terms of providing strategic direction for the digital transformation of their education system. This chapter seeks to investigate these challenges and present some promising policy approaches from OECD and EU countries. Some of the key questions that policy makers need to consider include:

- How might strategies for digital education support the implementation of digital education policies and enhance their coherence?
- Which other policies outside and within the education realm might affect digital education and how can synergies with the strategic vision be maximised?
- What role can strategies for digital education play in co-ordinating the responsibilities of different actors and levels of policy implementation?
- How can we ensure the status of strategies for digital education as living documents that are equipped to adapt to fast-changing technological environments and are responsive to experience and feedback?

Recent developments and current challenges

The landscape of digital education strategies is fast-changing and differs significantly across OECD countries

A review of the current strategies for digital education across OECD and EU member countries (Box 2.1 and Annex 2.A) underlines the fast-changing nature of digitalisation policies. Several countries have updated their digital education strategies since the outbreak of the pandemic: out of 45 OECD and EU countries reviewed, two-thirds released or updated strategic documents with at least some implications for digital education, and ten countries released substantive new strategic documents for digital education.

However, strategic activity in the field is not spread equally across OECD countries. Several southern and eastern European countries – including Italy, Portugal, Spain, Lithuania and Croatia – have introduced new digital education strategies over the last years, closing the ranks with central and northern European countries that had demonstrated long-standing efforts in the area. Within Europe, most strategic effort stems from countries in the mid-range of their digital development, as indicated by the Digital Economy and Society Index (DESI) (European Commission, 2022[1]). On the other hand, digital education still only receives limited attention in countries on the lower end of the spectrum of digital development (based on the DESI Index) such as Romania, Bulgaria or Poland. Similarly, beyond the EU, OECD countries at the early stages of their digital development as indicated by their performance along OECD Going Digital Indicators - such as the Republic of Türkiye, Chile and Costa Rica - make little mention of digital education in their strategic government documents (OECD, 2023[2]).

The governance arrangements of education systems are also reflected in the current provisions. In some federal countries, a lack of central steering powers on education matters precludes the possibility of binding central-level strategies for digital education. In such countries national authorities thus tend to provide guidance with a non-binding character (e.g. United States) or develop strategies for digital education at the subnational – rather than national – level (e.g. Australia and Canada).

Box 2.1. OECD data collection on high-level strategies for digital education in 2022

The fast-changing nature of digital education and continuous strategic work of OECD and EU countries on the topic require regular efforts to update and revise comparative analyses on strategies for digital education. Evidence on digital education strategies across OECD and EU countries was gathered through a 2022 OECD data collection exercise, building on and updating previous work on this topic (van der Vlies, 2020[3]; European Commission/EACEA/Eurydice, 2019[4]). For EU countries, the data collection involved exchanges with Eurydice country units within national ministries of education to obtain further information on countries' strategic work on digital education. In addition, experts from across OECD countries were asked to comment on the outcome of the data collection at the 8th meeting of the Group of National Experts on School Resources in March 2023. Detailed results of this data collection – including references to the most up-to-date strategic documents on digital education and when they were released – are presented in Annex Table 2.A.1.

Even where high-level strategies for digital education exist, there remains significant variance with respect to the content, depth of discussion, and concreteness of the goals formulated. For example, differences can be observed in the types of uses of digital technology targeted by strategic documents (e.g. whether they contain clauses on advanced technologies) and the extent to which they are linked to specific implementation instruments. The subsequent sections explore the current landscape of high-level digital education strategies in OECD and EU countries and illustrate how it has evolved in recent years.

Less than half of OECD and EU countries had an up-to-date strategy specifically for digital education both before and after the pandemic

Prior to the pandemic, the vast majority of OECD and EU countries covered strategic aspects of digital education in a specific strategic document or as part of a broader strategy (for instance, on education or digital innovation). However, less than half of OECD and EU education systems had a strategy *specifically* for digital education as shown in Figure 2.1.

While broader strategies have the potential advantage of aligning policies for digital education with wider social and education goals, they often provide only a brief and superficial discussion of digital education issues. **Germany** provides an example for a country that combines the benefits of both types of strategies. Next to its specific strategy for digital education which is implemented through the 'digital school pact' (Kultusministerkonferenz, 2017[5]; Bundesministerium für Bildung und Forschung, 2022[6]), the German federal government has recently published an overarching strategy for the implementation of digitalisation reforms (Die Bundesregierung, 2021[7]). This broader strategy provides a detailed catalogue of digitalisation initiatives planned across a range of policy areas, featuring concrete goals and implementation steps for each project. By including the 'digital school pact' as one of these initiatives, the strategy links education sector specific objectives with broader digitalisation goals.

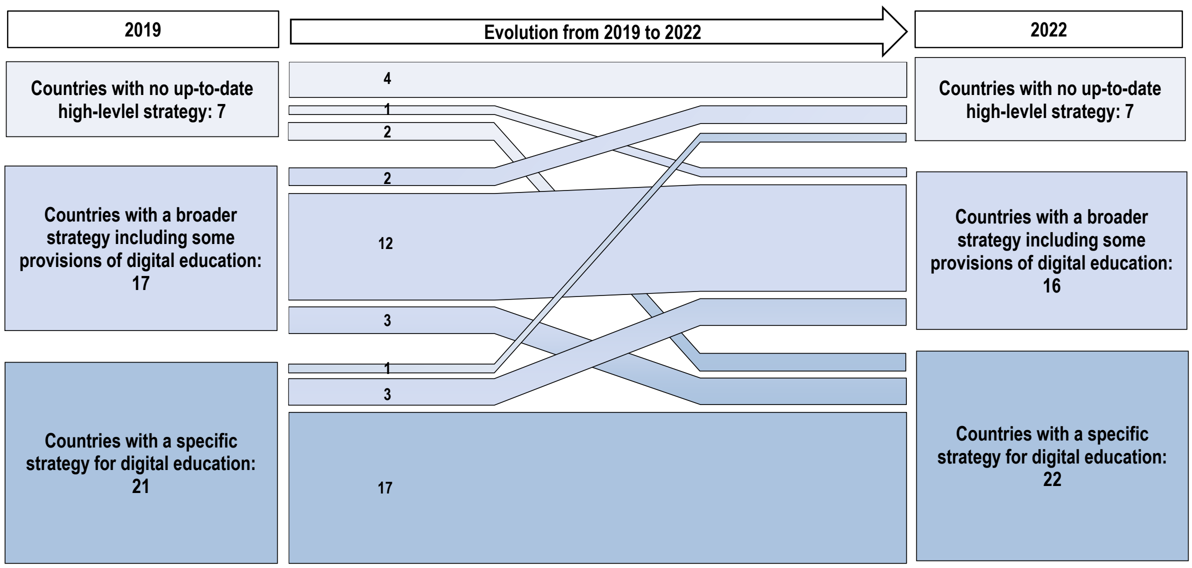
Including digital education in a broader strategy on digital innovation or skills also risks a misalignment of goals: while digital education strategies should focus on how digital technologies can support better *education outcomes*, broader strategies for digital innovation or skills usually narrowly discuss education as a means to boost digital skills for innovation or economic progress (van der Vlies, 2020[3]). Indeed, the promotion of skills for the digital transformation featured as one of the top digital policy objectives of OECD countries in 2016 and 2019. In 2016, for example, all 38 countries that replied to the OECD Digital Economy Policy Questionnaire had at least one type of ICT education and training policy in place (OECD, 2017[8]). Yet, digital technologies can improve a range of education outcomes, far beyond the acquisition of digital skills. For example (as discussed in Chapter 3), well-designed and implemented learning analytics can improve the quality of education provision at all levels of education. Considering digital education solely through the lens of developing digital skills is thus insufficient to unlock its full potential.

Prior to the pandemic, a Eurydice review of education systems included a stocktake of specific and broader strategies for digital education in European countries (European Commission/EACEA/Eurydice, 2019[4]). In the data collection process described in Box 2.1, the OECD updated this information in 2022 and complemented it with data on OECD countries outside Europe. Figure 2.1 below illustrates how the strategic provisions in OECD and EU countries have changed over time (differentiating between specific strategies, broad strategies or no strategic objectives for digital education). The graph indicates that the overall number of education systems that have specific strategies for digital education remained roughly the same between 2019 and 2022 at around half of OECD or EU member countries. Since the pandemic, only two countries that did not have a strategic vision specifically for digital education introduced a comprehensive strategy dedicated to this topic (**Lithuania** and the **Netherlands**). Another three education systems, which previously captured their objectives for digital education in broader strategies, released more comprehensive specific guidance (**Croatia**, the **Flemish Community of Belgium** and **Finland**).

This relatively low number of countries that introduced new specific strategic guidance for digital education since the pandemic contrasts with a high level of activity in updating strategic documents where they already existed in 2019: more than half of the 17 countries that already had a specific strategy for digital education in 2019 updated this strategy in the last three years. Out of these 17 countries, only one did not update its digital education strategy upon expiration whilst another three pivoted to including their objectives for digital education in broader strategies (Figure 2.1).

Figure 2.1. Evolution of high-level strategies for digital education in OECD and EU countries from 2019 to 2022

Existence of high-level strategies for digital education by type of strategy



Notes: This figure refers to broader strategies as national digital or education strategies with some provisions for digital education. In most cases, these strategies only take superficial notice of policies for digital education and do so only insofar as they promote digital innovation and a digital economy. Specific strategies for digital education have the goal of improving education outcomes through digital education and tend to provide more extensive and concrete digital education policy measures.
The figure includes information on the existence of high-level strategies for digital education from all OECD member countries (the Flemish, French- and German speaking communities of Belgium are counted separately) as well as of those non-OECD member countries that are part of the European Union (Croatia, Bulgaria, Romania, Cyprus and Malta).
Information on the existence of high-level strategies was collected from national administrative education units or through background research by the OECD. Annex Table 2.A.1 provides further details on the strategies for digital education as well as information on the sources of evidence.

The large investments in and expanded use of digital technology in recent years call for the continuation of a co-ordinated and strategic approach to digital education which builds the foundation for quality assurance, monitoring and evaluation. In fact, regular updates of strategies for digital education are necessary to ensure alignment with the evolution of technology and governments' strategic goals.

The strategic approach to digital education may also vary across levels and sectors of education. In higher education systems, for example, digital education objectives are often included in broader digital transformation strategies – such as the *Harnessing Digital: The Digital Ireland Framework* in **Ireland** (Government of Ireland, 2022[9]) – or in digital education strategies comprising the entire education system. However, some higher education systems have set plans exclusively focusing on higher education. **Hungary**, for example, adopted a Digital Education Strategy and Midterm Policy Strategy ("Shifting of Gears") that established system-wide higher education digitalisation objectives for the period 2016-20. **Finland,** too, has a dedicated digital strategy for its higher education system, Digivisio 2030 (Digivisio2030, n.d.[10]) while **Norway** has recently reviewed its higher education digitalisation strategy in light of the experience of the COVID-19 pandemic (Ministry of Education and Research, 2023[11]).

Where they exist, strategies for digital education are focused on basic technologies rather than advanced applications

In most OECD and EU countries, digital education strategies focus on digital infrastructure and digital learning environments, whilst addressing challenges of fostering digital competence and bridging digital divides (van der Vlies, 2020[3]). Improving access to high-speed Internet connection and digital devices (e.g. computers) is at the core of many national strategies for digital education. Objectives for digital learning environments focus either on easier access to quality learning resources or platforms for students and teachers (e.g. Massive Open Online Courses [MOOCs] and other digital educational resources), or on developing digital learning environments in schools and classrooms (e.g. through learning management and information systems). Digital education strategies also tend to focus on managing the challenges associated with digital education, including the development of digital skills (among students and teachers), bridging digital divides, and addressing privacy and security concerns.

Advanced technologies such as AI or blockchain rarely feature explicitly in digital education strategies of OECD and EU countries and – when mentioned – they are addressed in rather generic terms. **Japan** represents an exception to this pattern. Its strategy for digital education focuses on the use of advanced technology to support learning. While the strategy also touches on more common issues such as the availability of hardware and teachers' digital skills, many parts of the strategy are dedicated to themes such as the use of AI, virtual reality or big data in education (Ministry of Education, Culture, Sports, Science and Technology - Japan, 2019[12]).

Digital education strategies vary significantly in their depth and concreteness, and often lack implementation, governance and funding mechanisms

Even among countries with strategies for digital education, there is significant variation in the concreteness and depth of their objectives. Some strategies for digital education state rather aspirational goals and only discuss policies in broad general terms while others specify concrete, time-bound policy measures for each of their broader goals. In fact, digital education strategies often lack a concrete implementation roadmap (van der Vlies, 2020[3]), putting them at risk of only representing a statement of good will rather than having concrete policy implications. Evidence from EU countries also shows that digital education strategies often lack explicit monitoring or evaluation mechanisms (European Commission/EACEA/Eurydice, 2019[4]). Further analysis on this matter is provided in Chapter 9 of this report.

Systematic information on the governance structures for monitoring and co-ordinating the implementation of digital education strategies, on roles and responsibilities for implementation or on co-ordination mechanisms is often absent from digital education strategies. In countries that lack digital education strategies but where digital education is referred to in wider digital strategies, responsibilities for the development, implementation and monitoring are likely to be more scattered. An increasing number of countries allocate such responsibilities to a ministry, body or function in charge of digital affairs (Gierten and Lesher, 2022[13]). Though increasing in number, fewer countries allocate responsibility to an above-ministerial body or function which might be better positioned to align and co-ordinate policies (Gierten and Lesher, 2022[13]; OECD, 2019[14]).

Further, little is known about the budgets associated with digital education strategies as most of these documents do not explicitly reference underlying funding provisions. However, some information is available about the funding of general digital strategies. For countries that have a budget for their national digital strategy, financial resources are either explicitly attached to the strategy or draw on the budgets of different ministries or agencies with responsibility for the implementation of the strategy (OECD, 2020[15]; Gierten and Lesher, 2022[13]). Budgets explicitly tied to national digital strategies can better support co-ordination and enhance accountability. In contrast, more decentralised funding might simply be taken from ministries' existing funds and thereby result in underfunding (Gierten and Lesher, 2022[13]). In 2019, less than a third of the 34 countries covered by the OECD Digital Economy Policy Questionnaire had a digital budget explicitly tied to their national digital strategy (Gierten and Lesher, 2022[13]). This suggests that the majority of digital strategies lacked sufficient backing with funding mechanisms.

Achieving the goals of digital strategies may also be hampered by government policies that work at cross-purposes to their stated aims. In **Hungary**, for example, higher education institutional funding methodologies, regulation of education offerings, academic career policies, and the accreditation system were identified as having potentially limited the uptake of digital technologies in teaching and learning, as well as the extent of the offer of hybrid and online study programmes (OECD, 2021[16]). Subsequently, Hungary has commenced a number of reforms aiming at aligning its system features to support digital higher education, as part of its efforts to modernise higher education teaching and learning in general (OECD, 2023[17]).

Promising approaches to developing digital education strategies

This section outlines some promising policy approaches related to the development of digital education strategies, based on available evidence and recent national examples.

Recognise the benefits of a coherent and co-ordinated strategy for digital education, linked to concrete implementation instruments

A coherent and co-ordinated strategy reflecting a vision for digital education and underpinned by concrete funding and regulatory instruments can support more effective policy design and implementation. The OECD Policy Framework for Sound Public Governance highlights a number of baseline enablers of better policy design and implementation. Commitment, vision and leadership to enhance the sustainability of policies and reforms feature among these enabling factors (OECD, 2020[18]). Commitment for reform at the appropriate political level can be expressed through a government vision. Evidence from OECD country reviews shows that governments with capacity to formulate a strategic vision and effectively communicate it internally and externally are more likely to enhance policy coherence (OECD, 2020[18]).

Countries may have different rationales or objectives in their digital education strategies. Commitment to digital education reforms can vary, depending on education systems' state of digital development, budgetary pressures or alternative reform priorities. A strategy for digital education is not a necessary or mandatory condition for governments, but rather a highly desirable feature that will help communicate the vision and secure stakeholders' commitment. In addition, as illustrated by the analytical framework described in Chapter 1, a digital education strategy can specify in a co-ordinated way the implications of digital education for a range of policy areas, such as infrastructure, data privacy and security, human and financial resources, institutional capacity, and educators' professional learning.

A coherent and co-ordinated strategy for digital education can address existing challenges in the area of digital education more efficiently, better target resources to where they are most needed, and ensure that policy efforts have mutually reinforcing effects. When underpinned by concrete implementation instruments, including funding and regulation, a digital education strategy can increase countries' abilities to seize the potential of digital technologies for their education systems. In **Australia**, the Schools Digital Strategy of New South Wales provides an example of a coherent and co-ordinated digital education strategy (Box 2.2). Other notable examples include:

- The Digital Strategy for Schools to 2027 in **Ireland**, which relies on a three pillar approach that includes: i) embedding digital technologies in teaching, learning and assessment (taking a learner-centred approach and including objectives in the areas of school leadership, teachers professional learning, digital content, curriculum and assessment, etc.); ii) digital technology infrastructure (with objectives around the funding of digital infrastructure, the provision of broadband connectivity to schools, the provision of guidance and procurement mechanisms to schools, etc.) and a more forward-looking pillar around iii) policy, research and digital leadership (Department of Education Ireland, 2022[19]). The strategy builds upon and develops the priorities of the EU Digital Education Action Plan as well as of the wider Harnessing Digital – The Digital Ireland Framework. It is the result of extensive consultations with a range of stakeholders (education institutions, teachers, parents and students) and other countries with experience in the digitalisation of their education systems. An Implementation Plan is associated to the strategy, with a first implementation period covering 2023-2024, after which a review will be carried out which will support the preparation of a second implementation period.

- Similarly, the programme of school digitalisation until 2030 of the **Slovak Republic** revolves around strategic goals in five areas: i) digital infrastructure, ii) Electronic services and internal information system of the ministry, iii) Digital technologies and digital education content in the curriculum, iv) Skills and competences for the digital economy and v) Security in the information space (Ministry of Education of the Slovak Republic, 2021[20]). The Strategy is accompanied by an action plan which lists necessary policy actions with reference to the strategic goals for all relevant institutional players including the ministry, schools at primary and secondary level as well as universities. The actions are also assigned a concrete timeframe and funding channels (Ministry of Education of the Slovak Republic, 2021[21]).

Next to implementation instruments, some countries have introduced funding instruments for their digital education strategies:

- In **Germany**, the 'digital school pact' provides three billion euros of federal funding for the measures laid out in its digitalisation strategy. The German federal states have to report back to the central government on the implementation of the strategy, resulting in regular progress reports.
- Other countries have dedicated funding from the European Union for digital education. For instance, **Spain**'s latest strategy for digital education has budgeted EUR 301 million of funding from the Recovery, Transformation and Resilience Plan to the improvement of teacher digital competence. Similarly, the E-schools project in **Croatia** which implements digital reforms based on Croatia's strategy for digital education relies on funding from the European Regional Development Fund and the European Social Fund.

Align digital education strategies to the wider policy ecosystem

Strategies and policies for digital education cannot be conducted in isolation from policies outside of the education realm. Countries need connected, multi-dimensional policies to address the challenges and make the most of opportunities brought about by the digital transformation, with education and skills-related policies at the heart of their policy efforts (OECD, 2019[14]). Without co-ordination and the necessary policy framework in place (e.g. education policies, labour market policies), technological innovation is unlikely to translate into increased productivity (Andrews, Nicoletti and Timiliotis, 2018[22]).

Policies for digital education need to be aligned with other policy areas that matter for both the extent to which countries seize the general benefits of the digital transformation, and for enabling a successful digital education. In particular, a multi-sectoral policy effort is crucial for supporting access to and innovation in digital education infrastructure (Chapter 6). Co-ordinating education policies with policies outside of the education realm also matters for building capacity for digital education (Chapter 7). While teachers' and school leaders' professional learning falls within the scope of education policies, building capacity among local and sub-central authorities with responsibility for digital education and supporting parents as digital education facilitators likely requires policy efforts beyond the education sector. Such policies can include, for instance, labour market or social policies to address financial or time-related barriers to adult participation in training, and public employment policies.

Mapping the range of policies with implications for digital education that sit outside of the education realm, as well as their connections and complementarities with digital education policies is an important first step in the design of a comprehensive and co-ordinated policy ecosystem that can effectively enable and support digital education. While the exact connection of digital education polices with other policies will vary from one jurisdiction to another, if may often include, for example: telecom infrastructure-related policies, business environment and competition policies, labour market policies, regional development policies, regulatory policies regarding the use of digital tools and social policies that bear on participation in/support for education and training. For instance, the new strategy for digital transformation in the higher education sector in **Norway** was developed by the Ministry of Education and Research, in collaboration with a working group comprising education institution representatives, the business community, student organisations and the Norwegian Directorate for ICT and Joint Services in Higher Education and Research (UNIT – now subsumed into Sikt, a new organisation for the knowledge sector). The consultation process resulted in the identification of six different strategic priority areas, with associated action points for each strategic objective. The strategy also identified the other relevant policy developments in the sector, such as the strategy for flexible and decentralised education at vocational colleges, university colleges and universities, the white paper on data economy, and the national strategy for Artificial Intelligence (Ministry of Education and Research, 2023[11]).

Ensuring a co-ordinated policy approach for digital education also requires connecting digital education strategies to wider education system strategies and priorities. Indeed, the use of digital technologies is not an end in itself, but a means to education goals. Some countries have thus chosen to integrate their digitalisation-related objectives in their wider education strategies. This can be a promising approach, provided that it does not sacrifice the depth and comprehensiveness of the discussion of digital education. For instance, **Estonia** integrated a digital transformation programme in its lifelong learning strategy. While the strategy has the key goals of creating diverse and accessible learning opportunities, competent and motivated educators as well as learning options that are responsive to societal needs, concrete digitalisation reforms are proposed to achieve these objectives. The centrality of digital education in the Estonian education strategy is also reflected in the use of indicators on digital skills to benchmark the outcomes of the strategy (Ministry of Education and Research of the Republic of Estonia, 2021[23]).

A coherent approach to digital education spanning several education levels is also important. The integration of digital technologies in learning may involve different strategies at different ages. Education systems play a key role in developing the skills people need to thrive in a digital world whether at young ages (e.g. to help children navigate a digital world to which they are exposed increasingly early) or later in life (e.g. to adapt to changing labour markets or digital public services). Each education level is a building block for subsequent ones in supporting individuals to seize the potential of digital technologies for learning while mitigating associated risks. This requires in turn a continuum of digital education-related policies, tailored to specific challenges faced by individuals at different ages but embedded in a wider lifelong learning perspective. In **Hungary**, for example, the Digital Education Strategy has a pillar structure, following students' learning path throughout all levels of public education to higher education and adult learning, while a set of horizontal pillars span the sectors of education (e.g. monitoring learning paths, accessibility for persons with disabilities, security) (Digital Success Programme, 2016[24]).

Account for the governance arrangements of education systems, while aiming for policy coherence

While digital education policies should be aligned with the wider policy ecosystem, they also require co-ordination between different education policy levers (e.g. combining infrastructure investments with capacity building) and the different levels of policy intervention involved in their implementation (e.g. between national and subnational authorities). There is a need to ensure that digital education strategies address the relevant policy levers at each level of the system and include mechanisms to communicate the intended goals to the respective authorities.

Delineation of responsibilities is key for the successful implementation of digital education strategies and the accountability of respective authorities, especially in education systems with complex governance structures.

Co-ordination efforts must also bridge the increasing complexity of education system governance. Most OECD and EU countries have experienced increased decentralisation and school autonomy over the past decades. In addition, a range of institutions and entities are involved in the governance of education systems (such as quality assurance agencies, inspectorates, funding agencies and professional learning organisations.). Thus, multi-level decision-making processes with fluid links between actors at different levels increasingly characterise governance arrangements in OECD systems (OECD, n.d.[25]; Burns and Köster, 2018[26]).

In such a context, there is no "one-size fits all" approach for the governance of digital education strategies or policies. Governments need to give consideration to the allocation of roles and responsibilities throughout the system that best suits their context, strengthen co-ordination mechanisms and ensure that the different entities or levels of government in charge of digital education have sufficient capacity to deliver on their responsibilities (OECD, 2018[27]). Planning and implementation of digital education policies also requires careful consideration and understanding of decision making regarding the use of digital technologies in education.

Horizontal co-ordination mechanisms can be promoted at the different levels of the system, whether through specific co-ordination structures at the central level (e.g. the **Digital Luxembourg** initiative, Box 2.2) or at lower levels of the system (e.g. by providing guidance, supporting platforms for collaboration, pooling of administrative resources across schools or municipalities, or regulating co-operation) (OECD, 2018[27]). The need for co-ordination is increasingly recognised by governments. In **France**, for example, the Economic, Social and Environmental Council, a consultative assembly to the government and parliament, has called for more co-constructed policy efforts for digital education between the central administration, local and regional authorities (Gariel, 2021[28]).

In more decentralised education systems, policy efforts should aim to set and communicate the strategic directions at central level, devise adequate steering mechanisms and incentive structures for lower levels of governance, and build capacity at the lower levels of the system (e.g. regional and local authorities and schools) which hold ultimate responsibilities for planning and decision making in the area of digital education.

Box 2.2. Examples of co-ordinated policy approaches for digital education and skills strategy development

Co-designing comprehensive strategies to guide policy development and implementation for digital education: The New South Wales Schools Digital Strategy (Australia)

The government of New South Wales has designed a Schools Digital Strategy that provides a seven-year roadmap to enable schools and learners to develop and thrive in the area of digital education. The Strategy is the result of a two-year long process in which the government engaged with leaders, teachers and support staff in schools throughout New South Wales to understand their challenges and reflect on potential solutions (NSW Government, 2022[29]). The Strategy puts forward five investment themes: Digital Support & Innovation Digital Devices; Network & Infrastructure; Digital Maturity & User Capacity; Digital Content, Experience & Data. Investments in these areas will be based on previous and existing investments of the Department of Education and will be targeted across students and schools depending on their identified needs. The Department of Education and the New South Wales

Treasury also co-designed an investment logic map for the strategy that examines the opportunities, drivers and initiatives to be implemented, as well as expected outputs (NSW Department of Education, 2019[30]).

The Schools Digital Strategy is specifically linked to a range of other government strategies and policies, including Digital NSW (the digital strategy of New South Wales), the Department of Education Strategic Plan 2018-2022, the Connecting Metro/Country Schools Program (with a focus on schools' physical infrastructure) and the 20-Year Economic Vision for Regional New South Wales (NSW Department of Education, 2019[30]).

Fostering horizontal government co-ordination for the digital age: the Digital Luxembourg initiative

The Digital Luxembourg initiative was created in 2014 to support the country's digitalisation and skills development policies. It is a horizontal and multidisciplinary government initiative that involves more than 60 public and private stakeholders from a range of areas, including ministries, researchers, innovators, the NGO sector and companies (OECD, 2019[14]; Digital Skills and Jobs Platform, 2021[31]). The initiative is co-ordinated by the Department of Media, Connectivity and Digital Policy and takes a holistic policy approach, focusing on the improvement of digital skills, the development of a digital ecosystem (e.g. through digital tech funding), the design of policies for the digital era (including open data regulations), digital infrastructure investments and e-government (SMC, 2022[32]; OECD, 2019[14])). While the initiative is not focused on digital education per se, it has supported more than 25 projects focused on the development of digital skills and the effective use of digital technologies in education (e.g. projects focused on coding, game development or big data analysis in schools). Digital Luxembourg supports new or existing projects for digital transformation, by enabling public-private partnerships, facilitating access to funding and enhancing the projects' visibility (Digital Luxembourg, n.d.[33]).

While at the time of its launch, digitalisation initiatives in Luxembourg remained relatively limited and scattered, the Digital Luxembourg initiative has resulted in a wealth of digitalisation-related projects underpinning a broader national strategy (Digital Luxembourg, 2020[34]). For instance, in the area of skills development for digital education, the initiative has enabled the transition from a handful of training opportunities for selected groups to comprehensive and broad training targeted at all citizens (from school education to universities, businesses and training centres). It is increasingly expanding its focus on the development of advanced digital skills for AI or blockchain. Digital Luxembourg also helped set up an innovation ecosystem in Luxembourg, through seed funding for tech start-ups via the Digital Tech Fund (a joint public-private partnership launched in 2016) (Trésorerie de l'Etat - Luxembourg, 2016[35]; Digital Luxembourg, 2020[34]).

Adapt digital education strategies and policies to emerging technology requirements and needs

As new digital technologies become available to support teaching and learning processes, education policy makers need access to updated information about technological evolutions and associated requirements (e.g. in terms of network bandwidth, computing power, data storage, training, update and maintenance). Performing horizon scanning and taking stock of technological evolutions and developments can enhance the preparedness of education systems in an ever-changing digital field. Evidence on how countries currently examine the evolution of digital education technologies is often anecdotal, but some countries have dedicated institutional arrangements to examine technological developments and their implications for education systems:

- In **Switzerland**, Educa is the specialist agency for digital technologies and education set up by the Swiss Conference of Cantonal Ministers of Education and the State Secretariat for Education, Research and Innovation. It tracks developments in digital technologies with a focus on their application in education, assessing them and their potential use with respect to the strategic goals of the Confederation and the cantons in terms of enhancing the quality of education (Educa, n.d.[36]). It also provides support to the education sector in preparing to address challenges related to digital education, and it develops and disseminates knowledge and expertise on an effective use of digital technologies in education. Its priority areas of focus and projects are adapted regularly depending on evolving needs. Beyond evolving technology requirements, digital education strategies or overarching policies may also need further adaptation based on emerging feedback or needs from the field.

- In the **United States**, the Office for Educational Technology of the Department of Education is responsible for guiding and overseeing the use and integration of technology in American education systems (Office of Educational Technology, n.d.[37]). Part of its mission is to ensure equity of access to the enhanced learning experiences made possible by technological developments. To that end, it conducts research on cutting edge technologies and their implications for education systems and makes the results widely available. It also provides information to state authorities, school districts and others about the available means to fund and use digital technologies in education systems. Its activities are intended to improve learning outcomes across education systems, including for K-12 education, higher education and adult education.
- **Italy'**s National Institute for Documentation, Innovation and Educational Research (INDIRE), a research organisation of the Ministry of Education, researches and tests new technologies for improving teaching and learning, including emerging technologies (INDIRE, n.d.[38]). For example, a current research project (funded by ERASMUS+) evaluates different approaches to the use of AI in teaching and learning.
- Other countries, such as **Germany**, have designed their digital strategies as living documents that they update on a regular basis (Gierten and Lesher, 2022[13]).

Key messages

Policies for digital education require the mobilisation of several policy levers and co-operation with a range of stakeholders. These complexities call for a co-ordinated approach. A well-designed strategy for digital education which is aligned with the wider policy ecosystem and specific national governance arrangements can help to tie together the relevant policy streams and provide an overarching vision for digital education.

Currently, countries across the OECD and EU differ significantly in the extent to which they leverage strategic documents to co-ordinate digital education policies: Some countries provide nuanced strategic documents specifically for digital education whilst others treat digital education only superficially in broader strategies on education or digital skills. The chapter also presents some examples of strategic visions which are paired with concrete funding and implementation instruments – such as time-bound action plans or designated budgets for digital education.

Regardless of the type of strategic document, most OECD and EU countries limit their strategic aims to basic uses of digital technologies: Advanced technologies – such as AI or blockchain – are rarely featured in strategies for digital education in OECD and EU countries. However, the chapter emphasises the importance of taking a forward-looking approach to strategic planning to provide effective guidance for digitalisation of education systems in the medium run and to unlock the full potential of digital technologies. Beyond considering already available uses of advanced technologies, this calls for further efforts to anticipate upcoming technological trends and their implications for education systems as well as including mechanisms to update and adjust strategic goals to the latest technological developments.

References

Andrews, D., G. Nicoletti and C. Timiliotis (2018), “Digital technology diffusion : A matter of capabilities, incentives or both?”, *OECD Economics Department Working Papers*, No. 1476, OECD Publishing, Paris, https://www.oecd-ilibrary.org/economics/digital-technology-diffusion_7c542c16-en (accessed on 16 June 2022). [22]

Bundesministerium für Bildung und Forschung (2022), *Fortschrittsbericht DigitalPakt Schule 2019-2022*, https://www.digitalpaktschule.de/files/220616_DigitalPaktSchule_Fortschrittsbericht_barrierefrei.pdf (accessed on 5 December 2022). [6]

Burns, T. and F. Köster (2018), *Educational Research and Innovation Governing Education in a Complex World*, , Educational Research and Innovation, OECD Publishing, Paris. [26]

Department of Education Ireland (2022), *Digital Strategy for Schools to 2027*, https://www.gov.ie/en/publication/69fb88-digital-strategy-for-schools/#digital-strategy-for-schools-to-2027 (accessed on 26 August 2022). [19]

Die Bundesregierung (2021), “Digitalisierung gestalten :Umsetzungsstrategie der Bundesregierung”, https://www.bundesregierung.de/resource/blob/975292/1605036/339a38c264fd50ff9efca6ad8da64bae/digitalisierung-gestalten-download-bpa-data.pdf?download=1 (accessed on 17 June 2022). [7]

Digital Luxembourg (2020), *Progress report*, https://digital-luxembourg.public.lu/sites/default/files/2021-02/DL_202005039_PROGRESS%20REPORT2019_low2.pdf (accessed on 25 August 2022). [34]

Digital Luxembourg (n.d.), *About Us | Digital Luxembourg*, https://digital-luxembourg.public.lu/about-us (accessed on 29 June 2022). [33]

Digital Skills and Jobs Platform (2021), *Luxembourg - Digital Luxembourg Initiative*, https://digital-skills-jobs.europa.eu/en/actions/national-initiatives/national-strategies/luxembourg-digital-luxembourg-initiative (accessed on 29 June 2022). [31]

Digital Success Programme (2016), “Digital Education Strategy of Hungary”, https://digitalisjoletprogram.hu/files/0a/6b/0a6bfcd72ccbf12c909b329149ae2537.pdf (accessed on 5 December 2022). [24]

Digivisio2030 (n.d.), *Etusivu*, https://digivisio2030.fi/ (accessed on 23 August 2022). [10]

Educa (n.d.), *Specialist agency | Educa*, https://www.educa.ch/en/about-us/specialist-agency (accessed on 30 June 2022). [36]

European Commission (2022), *DESI by components — Digital Scoreboard - Data & Indicators*, https://digital-agenda-data.eu/charts/desi-components#chart={%22indicator%22:%22desi%22,%22breakdown-group%22:%22desi%22,%22unit-measure%22:%22pc_desi%22,%22time-period%22:%222022%22} (accessed on 7 March 2023). [1]

European Commission/EACEA/Eurydice (2019), *Digital Education at School in Europe*, Eurydice Report. Luxembourg: Publications Office of the European Union, https://eacea.ec.europa.eu/national-policies/eurydice/content/digital-education-school-europe_en (accessed on 4 August 2020). [4]

Gariel, M. (2021), *L'école à l'ère du numérique -Avis du Conseil économique, social et environnemental*, Conseil économique, social et environnemental. [28]

Gierten, D. and M. Lesher (2022), "Assessing National Digital Strategies and their Governance", *OECD Digital Economy Papers*, No. 234, OECD Publishing, Paris, http://www.oecd.org/termsandconditions. (accessed on 16 June 2022). [13]

Government of Ireland (2022), *Harnessing Digital - The Digital Ireland Framework*, https://www.gov.ie/en/publication/adf42-harnessing-digital-the-digital-ireland-framework/#the-plan (accessed on 23 August 2022). [9]

INDIRE (n.d.), *Artificial Intelligence for and by teachers (AI4T): the evaluation of interventions – Indire*, https://www.indire.it/en/progetto/artificial-intelligence-for-and-by-teachers-ai4t-the-evaluation-of-interventions/ (accessed on 11 April 2023). [38]

Kultusministerkonferenz (2017), "Bildung in der digitalen Welt", https://www.kmk.org/fileadmin/Dateien/pdf/PresseUndAktuelles/2018/Digitalstrategie_2017_mit_Weiterbildung.pdf (accessed on 5 December 2022). [5]

Ministry of Education and Research (2023), "Strategy for digital transformation in the higher education sector", https://www.regjeringen.no/en/dokumenter/strategy-for-digital-transformation-in-the-higher-education-sector/id2870981/ (accessed on 11 April 2023). [11]

Ministry of Education and Research of the Republic of Estonia (2021), *Strategic planning for 2021–2035*, https://www.hm.ee/en/ministry/ministry/strategic-planning-2021-2035#documents (accessed on 5 December 2022). [23]

Ministry of Education of the Slovak Republic (2021), *Action plan for informatisation and digital transformation of education in the Slovak Republic for the period 2021-2024*, https://www.minedu.sk/data/att/23247.pdf (accessed on 9 December 2022). [21]

Ministry of Education of the Slovak Republic (2021), *Programme of school informatisation until 2030*, http://www.minedu.sk (accessed on 9 December 2022). [20]

Ministry of Education, Culture, Sports, Science and Technology - Japan (2019), *Measures to Promote the Use of Advanced Technology to Support Learning in the New Era*, https://www.mext.go.jp/component/a_menu/other/detail/__icsFiles/afieldfile/2019/06/24/1418387_02.pdf (accessed on 14.12.2022). [12]

NSW Department of Education (2019), "Service Need and Alignment Investment Logic Map (ILM)". [30]

NSW Government (2022), *Roadmap*, https://education.nsw.gov.au/about-us/strategies-and-reports/schools-digital-strategy/roadmap (accessed on 27 June 2022). [29]

OECD (2023), *Ensuring Quality Digital Higher Education in Hungary*, Higher Education, OECD Publishing, Paris, https://doi.org/10.1787/5f44fd6f-en. [17]

OECD (2023), *OECD Going Digital*, https://goingdigital.oecd.org/countries (accessed on 7 March 2023). [2]

OECD (2021), *Supporting the Digital Transformation of Higher Education in Hungary*, Higher Education, OECD Publishing, Paris, https://doi.org/10.1787/d30ab43f-en. [16]

OECD (2020), *OECD Digital Economy Outlook 2020*, OECD Publishing, Paris, https://www.oecd-ilibrary.org/docserver/bb167041-en.pdf?expires=1649407912&id=id&accname=ocid84004878&checksum=622C667A00E953D9887D14298488AF4C (accessed on 8 April 2022). [15]

OECD (2020), *Policy Framework on Sound Public Governance: Baseline Features of Governments that Work Well,*, OECD Publishing, Paris, https://www.oecd-ilibrary.org/docserver/c03e01b3-en.pdf?expires=1655300670&id=id&accname=ocid84004878&checksum=DB3D175D6D9FF20EA550CAC45EB1E755 (accessed on 15 June 2022). [18]

OECD (2019), *OECD Skills Outlook 2019: Thriving in a Digital World*, OECD Publishing, Paris, https://doi.org/10.1787/df80bc12-en. [14]

OECD (2018), *Responsive School Systems: Connecting Facilities, Sectors and Programmes for Student Success*, OECD Reviews of School Resources, OECD Publishing, Paris, https://doi.org/10.1787/9789264306707-en. [27]

OECD (2017), *OECD Digital Economy Outlook 2017*, OECD Publishing, Paris, https://doi.org/10.1787/9789264276284-en. [8]

OECD (n.d.), "OECD Review of Policies to Improve the Effectiveness of Resource Use in Schools (School Resources Review) : Design and Implementation Plan for the Review". [25]

Office of Educational Technology (n.d.), *What We Do - Office of Educational Technology*, https://tech.ed.gov/what-we-do/ (accessed on 11 April 2023). [37]

SMC (2022), *Digital Lëtzebuerg*, https://smc.gouvernement.lu/en/dossiers.gouvernement%2Ben%2Bdossiers%2B2014%2Bdigital-letzebuerg.html (accessed on 29 June 2022). [32]

Trésorerie de l'Etat - Luxembourg (2016), *Digital Tech Fund - Participations de l'Etat*, https://te.public.lu/fr/participations/societes_droit_prive/non_cotees_en_bourse/Digital_tech_fund.html (accessed on 25 August 2022). [35]

van der Vlies, R. (2020), "Digital strategies in education across OECD countries: Exploring education policies on digital technologies", *OECD Education Working Papers*, No. 226, OECD Publishing, Paris, https://doi.org/10.1787/33dd4c26-en. [3]

Annex 2.A. High-level strategies for digital education

Annex Table 2.A.1. Collection of high-level strategies for digital education across OECD and EU countries

Country	High-Level Strategy or related documents	Notes on high-level strategy
Australia	**Digital Economy Strategy 2030** https://digitaleconomy.pmc.gov.au/sites/default/files/2021-07/digital-economy-strategy.pdf Examples for sub-central strategies: • Schools Digital Strategy (New South Wales) • https://education.nsw.gov.au/about-us/strategies-and-reports/schools-digital-strategy • Digital Strategy 2022-2025 (South Australia): • https://discover.education.sa.gov.au/digital-strategy/index.html • Digital Strategy 2022-2026 (Queensland) • https://alt-qed.qed.qld.gov.au/publications/strategies/digital-strategy	Australia's broader Digital Economy Strategy for 2030 discusses some measures for digital education on a national level in its skills and inclusion section. However, several states and territories have released their own specific strategies for digital education.
Austria [C]	**8-point plan 'digital school'** https://digitaleschule.gv.at/	Austria published a specific plan for digital education in 2020. The plan pins down eight concrete goals for school digitalisation.
Belgium (FL)	**Vision note 'Digisprong'** https://publicaties.vlaanderen.be/view-file/40711	In 2020, the Flemish Community of Belgium introduced a specific strategy for digital education which sets out goals and concrete action points for school digitalisation.
Belgium (FR) [C]	**Stratégie numérique pour l'éducation** http://enseignement.be/download.php?do_id=14908	The Digital Strategy for Education of the French Community of Belgium was passed in 2018 and sets out key action priorities along five axes of school digitalisation.
Belgium (GE) [C]	**Guidelines for Information and Media Literacy** https://ostbelgienbildung.be/PortalData/21/Resources/downloads/schule_ausbildung/schulische_ausbildung/130916-LEITFADEN_IMK_-_Gesamtdokument.pdf	The German-speaking Community of Belgium currently has no top-level education digitalisation strategy. The 'Guidelines for Information and Media Literacy' provide some orientation for school digitalisation, however, without a binding character. The guidelines are currently under revision to reflect the Community's increasing concern in digital education.
Bulgaria [C]	**National Program Digital Bulgaria 2025** https://www.mtc.government.bg/en/category/85/national-program-digital-bulgaria-2025-and-road-map-its-implementation-are-adopted-cm-decision-no73005-12-2019 **Digital Transformation of Bulgaria for the period 2020-2030** https://www.strategy.bg/StrategicDocuments/View.aspx?lang=bg-BG&Id=1318 **Bulgaria 2030** https://www.minfin.bg/en/1394	Bulgaria's specific education sector strategy (strategy for the effective application of digital technologies in education) expired in 2020. After that, the objectives of the strategy were adopted into a range of strategies with a broader focus.
Canada	**Canada's Digital Charter: A plan by Canadians, for Canadians** https://ised-isde.canada.ca/site/innovation-better-	On a national level, the 'Canada's Digital Charter' provides a broader strategy for digitalisation which also touches upon digital education. In addition, some provinces - such as Quebec - have introduced their own

Country	High-Level Strategy or related documents	Notes on high-level strategy
	canada/en/canadas-digital-charter/canadas-digital-and-data-strategy Examples for sub-central level strategies: • **Digital action plan in education and higher education (Plan d'action numérique en éducation et en enseignement supérieur)** (Quebec) http://www.education.gouv.qc.ca/dossiers-thematiques/plan-daction-numerique/plan-daction-numerique/	strategies at a sub-central level.
Chile	**Strategy for Digital Transformation 2035 (Estrategia de Transformación digital Chile Digital 2035)** https://www.cepal.org/sites/default/files/events/files/estrategia_de_transformacion_digital_chile_2035_final_.pdf	Chile's broad strategy for digital transformation briefly names improving educational quality through digital technologies as one of its objectives. However, the section dedicated to this goal is very short.
Colombia	**Technologies to learn: National policy to promote the innovation in educational practices through digital technologies** https://colaboracion.dnp.gov.co/CDT/Conpes/Econ%C3%B3micos/3988.pdf **Plan TIC - The digital future belongs to everyone (Plan TIC El Futuro Digital es de Todos)** https://mintic.gov.co/portal/inicio/Atencion-y-Servicio-a-la-Ciudadania/Preguntas-frecuentes/107127:El-futuro-digital-es-de-todos	Colombia's specific strategy for digital education "Technologies for learning" was released in 2020 and builds on the Computers for Education (Computadores para educar) project. Apart from an extensive assessment of the state of digitalisation of Colombia's school system, the strategy presents several lines of actions going forward and identifies the relevant time frames for implementation. An action and monitoring plan in the annex of the strategy keeps track of the extent to which the specified objectives are accomplished over time and the financial resources invested in them. More broadly, the Plan TIC sets digitalisation goals for the wider economy and society, including some goals for the digitalisation of schools. The goals are complemented by corresponding indicators which the Ministry of Information Technologies and Communications uses to track the progress of digitalisation in quarterly reports.
Costa Rica	**National Development Plan for Telecommunications 2022-2027 (Plan Nacional de Desarrollo de las Telecomunicaciones 2022-2027)** https://www.crhoy.com/wp-content/uploads/2022/08/PNDT-2022-2027-Versio%CC%81n-09-agosto-2022.pdf	Costa Rica has introduced an updated board digital strategy in 2022. While the plan states the fostering of digital skills as one of its key policy goals, it hardly makes direct reference to schooling and higher education policies.
Czech Republic C	**Strategy for the Education Policy of the Czech Republic up to 2030+** https://www.msmt.cz/uploads/brozura_S2030_en_fin_online.pdf	The specific education sector strategy of the Czech Republic (Digital Education Strategy 2020) expired in 2020. After that, the country's objectives regarding the digitalisation of the education sector were integrated into its broader education sector strategy which briefly addresses digital education in one of its sub-sections.
Croatia C	**Strategic Framework for Digital Maturity of Schools and the School System in the Republic of Croatia (2030)** https://www.carnet.hr/wp-content/uploads/2020/03/Strateski-okvir-za-digitalno-sazrijevanje-skola-i-skolskog-sustava-u-Republici-Hrvatskoj-2030.pdf	Croatia's specific strategy for digital education was developed as part of the Croatian E-Schools project. It defines the areas and levels of the digital maturity of schools and is co-ordinated with the European Framework for Digitally Competent Educational Organisations. The Framework covers five areas and five levels of the digital maturity of schools.
Cyprus	**Digital Skills National Action Plan 2021-2025** https://www.dmrid.gov.cy/dmrid/research.nsf/planning_el/planning_el?OpenDocument	The previous broader digitalisation strategy (Digital Strategy for Cyprus 2012-2020) explicitly suggested reforms in the education sector. To the author's best knowledge, the National Action Plan for Skills (2021-2025) now provides the most detailed up-to-date information on the cypriot school digitalisation endeavours.
Denmark C	**Denmark's digitalisation strategy - together on digital development** https://fm.dk/udgivelser/2022/maj/danmarks-digitaliseringsstrategi-sammen-om-den-digitale-udvikling/ **2021 Policy agreement** https://www.uvm.dk/aktuelt/nyheder/uvm/2021/dec/211206-ny-aftale-skal-styrke-boern-og-unges-digitale-dannelse	Denmark's previous specific digitalisation strategy (Action Plan for Technology in Education) has been replaced by a new broad digital strategy which also includes its ambitions for the digitalisation of the education sector in a section on future-ready skills. In addition, Denmark has set aside DKK 52.5 million for digital education of children and young people through the 2021 Policy Agreement.

Country	High-Level Strategy or related documents	Notes on high-level strategy
Estonia C	**Education Strategy 2021-2025** https://www.hm.ee/en/ministry/ministry/strategic-planning-2021-2035#documents	In 2021, Estonia introduced its new 'Education Strategy 2021-2035', a broad lifelong learning strategy which touches on digital skills in the context of making education responsive to social and labor market needs.
Finland C	**New Literacies Programme for 2020-2023** https://uudetlukutaidot.fi/	Finland's 'New Literacies Programme' for the 2020-2030 period is part of the ministry's Right to Learn Program. The programme homepage provides detailed descriptions of the relevant ICT-related competences for different age groups.
France	**Stratégie numérique pour l'éducation 2023-2027** https://www.education.gouv.fr/strategie-du-numerique-pour-l-education-2023-2027-344263	France released a new digital strategy for education in January 2023 which sets out a vision for digital education policy benefitting students, their parents, teachers and all agents in the education ecosystem. The strategy sets out the goals for digital education until 2027 along four axes: creating an enabling governance ecosystem for digital education, developing citizenship and digital skills through digital education, supporting the education community for digital education and designing effective digital systems.
Germany C	**Education in the digital world** https://www.kmk.org/fileadmin/Dateien/pdf/PresseUndAktuelles/2018/Digitalstrategie_2017_mit_Weiterbildung.pdf **Supplementary recommendations on teaching and learning in the digital world** https://www.kmk.org/fileadmin/veroeffentlichungen_beschluesse/2021/2021_12_09-Lehren-und-Lernen-Digi.pdf **Recommendations for the digitalisation of teaching in higher education** https://www.kmk.org/fileadmin/Dateien/pdf/PresseUndAktuelles/2019/BS_190314_Empfehlungen_Digitalisierung_Hochschullehre.pdf **Progress report Digital Pact** https://www.digitalpaktschule.de/files/220616_DigitalPaktSchule_Fortschrittsbericht_barrierefrei.pdf	Germany introduced a strategy for 'Education in the digital world' in 2016 – a comprehensive digitalisation strategy covering school- and higher education – which was complemented with further recommendations on digital teaching and learning in 2021. This strategy built the foundation for digitalisation reforms such as the recent 'Digital Pact' which provides large-scale national support for federal states to invest in digital infrastructure. Separate recommendations exist for the higher education level.
Greece	**Digital Transformation Bible 2020-2025** https://digitalstrategy.gov.gr/	The Greek 'digitalisation bible 2020-2025' exemplifies a broad digitalisation strategy with substantive provisions for digital education covering all education levels.
Hungary C	**Digital Education Strategy of Hungary** https://digitalisjoletprogram.hu/files/0a/6b/0a6bfcd72ccbf12c909b329149ae2537.pdf **Public Education Strategy 2021-2030** https://2015-2019.kormany.hu/download/d/2e/d1000/K%C3%B6znevel%C3%A9si%20strat%C3%A9gia.pdf	Hungary released a detailed specific strategy for digital education in 2016. No update has been issued since. However, the Public Education Strategy for 2021-2030 also includes provisions for digital education.
Iceland	**n/a**	To the authors' best knowledge, Iceland does currently not have a strategy for digital education.
Ireland	**Digital Strategy for Schools to 2027** https://www.gov.ie/en/publication/69fb88-digital-strategy-for-schools/#:~:text=See%20Also-,Overview,an%20ever%20evolving%20digital%20world.	Ireland recently introduced a specific strategy for digital education which covers the 2022-2027 period and will be accompanied by an action plan with concrete and time-bound policy actions.
Israel	**National Digital Program** https://www.gov.il/BlobFolder/news/digital_israel_national_plan/en/The%20National%20Digital%20Program%20of%20the%20Government%20of%20Israel.pdf	In its 2017 broad digital strategy, Israel sets out a vision for digitalisation of a range of sectors. There is a brief section dedicated to formal education specifically, although education is touched upon several times as a crosscutting theme.
Italy C	**Piano Scuola 4.0**	Italy launched a specific strategy for digital education in 2022 as foreseen by the national plan for recovery and resilience. It includes two main initiatives

Country	High-Level Strategy or related documents	Notes on high-level strategy
	https://pnrr.istruzione.it/wp-content/uploads/2022/07/PIANO_SCUOLA_4.0_VERSIONE_GRAFICA.pdf	focused on digital classroom infrastructure and fostering key digital skills.
Japan	**Promoting measures to utilise cutting-edge technology to support learning in a new era** https://www.mext.go.jp/a_menu/other/1411332.htm **Roadmap on the utilisation of data in education** https://www.digital.go.jp/assets/contents/node/basic_page/field_ref_resources/0f321c23-517f-439e-9076-5804f0a24b59/20220307_en_education_outline_01.pdf **Giga school program** https://www.japantimes.co.jp/2021/03/22/special-supplements/japans-giga-school-program-equips-students-digital-society/	In 2019, the Japanese Ministry of Education, Culture, Sports, Science and Technology introduced a specific strategy for digital education which – to the author's best knowledge - still represents the most comprehensive strategy for digital education. In 2021, the government of Japan passed the Basic Act on Forming a Digital Society which showcased Japan's commitment to fostering digital transformation and digital skills. Since then, the government made large investments in digital skills development, created the Digital Agency to co-ordinate the digital transformation and introduced several policy plans including the roadmap on the utilisation of data in education.
Korea	**Roadmap for Digital Talent Cultivation** http://english.moe.go.kr/boardCnts/viewRenewal.do?boardID=265&boardSeq=92601&lev=0&searchType=null&statusYN=W&page=1&s=english&m=0201&opType=N	The Korean government has recently announced to release a specific strategy for digital education with the aim to provide a million Koreans across education levels with the necessary digital skills by 2027. This plan follows previous white papers on ICT in Education. Further, there is a Information Education Plan on a provincial level which is updated annually but not publicly available.
Latvia [C]	**Digital Transformation Guidelines 2021-2027** https://digitalanedela.lv/wp-content/uploads/2021/09/Latvijas-Digit%c4%81l%c4%81s-Transform%c4%81cijas-pamatnost%c4%81dnes-2021-2027.pdf **Education Development Guidelines** https://eprasmes.lv/wp-content/uploads/2022/02/Latvijas-Izglitibas-attsitibas-pamatnostadnes-2021-2027.pdf	In Latvia, there are two broader strategies that have implications for education digitalisation: the Digital Transformation Guidelines 2021-2027 and the Education Development Guidelines 2021-2027.
Lithuania [C]	**Digital Transformation of Education** https://www.e-tar.lt/portal/lt/legalAct/254ed330b95e11ec8d9390588bf2de65	In 2021, Lithuania released the progress instrument 'Digital Transformation of Education' which pints down concrete actions for the digitalisation of education, building on the country's national development plan.
Luxembourg	**Einfach Digital** https://men.public.lu/fr/publications/dossiers-presse/2019-2020/einfach-digital.html'	In 2020, Luxembourg launched its new initative 'einfach digital', succeeding the previous 'digital4education' initiative. In a 2022 policy survey conducted by the OECD Centre of Education Research and Innovation (CERI), Luxembourg further expressed the intention of updating the current strategy with learnings from the pandemic in 2023.
Malta	**National E-Skills Strategy 2019-2021** https://eskills.org.mt/en/nationaleskillsstrategy/Documents/National_eSkills_strategy.pdf	Malta's broad strategy for digital education expired in 2021. However, to the author's best knowledge a new strategy is under development at the point of the writing of this document.
Mexico	**n/a**	To the author's best knowledge, Mexico does currently not have an up-to-date digitalisation strategy for the education sector.
Netherlands	**Digitalisation agenda for primary and secondary education** https://www.nederlanddigitaal.nl/binaries/nederlanddigitaal-nl/documenten/publicaties/2019/11/19/digitalisation-agenda-for-primary-and-secondary-education/Digitization+agenda+primary+and+secondary+education.pdf **Value-Driven Digitalisation Work Agenda** https://www.government.nl/documents/reports/2022/11/30/value-driven-digitalisation-work-agenda	In 2019, the Netherlands released its first specific strategy for digital education, aiming to set the course of digitalisation in education. In addition, the broader digital strategy 'Value-driven Digitalisation Work Agenda' covers a range of aspects regarding the integration of digital skills in curricula and providing support to school institutions to teaching these skills.

Country	High-Level Strategy or related documents	Notes on high-level strategy
New Zealand	**Digital Strategy for Aotearoa** https://www.digital.govt.nz/assets/Digital-government/Strategy/Digital-Strategy-for-Aotearoa-English-PDF.pdf	New Zealand's broad digital strategy discusses digital education as a cross cutting theme. In a 2022 policy survey conducted by the OECD Centre for Education Research and Innovation (CERI), New Zealand has declared intentions of reforming its strategic framework for digital education.
Norway	**Digitalisation strategy for Basic Education 2017-2021 (expired)** https://www.regjeringen.no/no/dokumenter/framtid-fornyelse-og-digitalisering/id2568347/ **Strategy for digital transformation in the higher education sector** https://www.regjeringen.no/en/dokumenter/strategy-for-digital-transformation-in-the-higher-education-sector/id2870981/	Norway's digitalisation strategies for higher and basic education both expired in 2021. To the best knowledge of the author, no further comprehensive strategy for digital education has been published since. In 2023, Norway updated its previous Digitalisation Strategy for the higher education sector to take into account lessons learned during the pandemic
Poland	**Outlook on the Strategy for Digital Competences** https://www.gov.pl/web/cyfryzacja/kompetencje-cyfrowe	Poland is currently in the process of developing a new strategy for digital competences.
Portugal C	**Digital Transition Action Plan** https://portugaldigital.gov.pt/wp-content/uploads/2022/01/Portugal_Action_Plan_for_Digital_Transition.pdf	Portugal's broad digitalisation strategy touches on school digitalisation under its pillar for 'Capacity building and Digital Inclusion'.
Romania C	**Government Plan 2021-2024** https://gov.ro/fisiere/programe_fisiere/Program_de_Guvernare_2021%E2%80%942024.pdf	Romania's broader digital strategy (Digital agenda) expired in 2020. No comprehensive plan for education digitalisation followed. However, the government's concern for digitalisation is reflected in the 2021 Government plan.
Slovak Republic C	**Programme of schools informatisation until 2030** https://www.minedu.sk/data/att/23246.pdf	In 2021, the government of the Slovak Republic passed a specific strategy for digital education which is supplemented by concrete action plans, the first of which covers the 2021-2024 period. This comprehensive strategy covers both school- and higher education.
Slovenia	**Digital education action plan**	In a 2022 policy survey conducted by CERI (OECD) Slovenia indicated to have released a digital education action plan within the last two years which has been developed through more than 30 workshops with various stakeholders
Spain C	**Plan for the Digitalisation and Digital Competences in the Education System** https://intef.es/Noticias/plan-de-digitalizacion-y-competencias-digitales-del-sistema-educativo-plan-digedu/ **National Plan for Digital Skills** https://portal.mineco.gob.es/RecursosArticulo/mineco/ministerio/ficheros/210902-digital-skills-plan.pdf	The Spanish Ministry of Education has recently launched a specific strategy for digital education (Plan for the Digitalisaiton and Digital Competences in the Education System) which determines four lines of action for digital education. This plan was created as one of the measures set out in the 2021-2025 National Skills Strategy.
Sweden C	**National Strategy for Digital education** https://www.regeringen.se/4a9d9a/contentassets/00b3d9118b0144f6bb95302f3e08d11c/nationell-digitaliseringsstrategi-for-skolvasendet.pdf	Sweden's specific strategy for digital education covers the time frame between 2017-2022. The National Agency for Education have been given the task to come up with a proposal for a new strategy on digital education covering the period 2023 to 2027.
Switzerland	**Strategy of the EDK for addressing the digital changes of the education sector** https://www.edk.ch/de/themen/transversal/digitalisierung?highlight=b8356241084a43b7af610deadca98a0a&expand_listingblock=1892124769a446d4993fdfbeb24a3106	On a national level, the EDK (Conference of the Education Directorates of the Swiss Cantos) has published shared goals for education digitalisation of all cantons with respect to school digitalisation in 2018. A further document was released to assign responsibilities among the Cantons and the EDK in achieving these goals.
Republic of Türkiye	**Education Vision for 2023** https://planipolis.iiep.unesco.org/sites/default/files/ressources/turkey_education_vision_2023.pdf	Türkiye's broad education strategy contains a short section on digital content and skills-backed transformation of the learning process.
United Kingdom	**Realising the potential of technology in Education** https://assets.publishing.service.gov.uk/government/uplo	In the UK, the most specific analysis of digital education policies is offered by the 2019 strategy on 'Realising the potential of technology in Education'.

Country	High-Level Strategy or related documents	Notes on high-level strategy
	ads/system/uploads/attachment_data/file/791931/DfE-Education_Technology_Strategy.pdf **UK digital strategy** https://www.gov.uk/government/publications/uks-digital-strategy/uk-digital-strategy#s3	More recently, the 'UK digital strategy' features a section on digital skills and talent that focuses, among other things, on the strengthening of digital skills through school and university education.
United States	**National Education Technology Plan** https://tech.ed.gov/netp/ **Reimagining the Role of Technology in Higher Education – Supplement to the National Education Technology Plan** https://tech.ed.gov/files/2017/01/Higher-Ed-NETP.pdf	In the United States, the National Education Technology Plan published by the Office of Educational Technology of the Department of Education represents a national strategy for digital education. While the latest version stems from 2017, the plan is currently under revision. A separate strategy document exists on the role of digital technologies in higher education.

Note: As part of the data gathering process, the OECD reached out to the national officials in the Eurydice country units of all EU member states. Superscript ''C'' in the country column indicates that the information displayed was obtained from national officials. For non-EU member countries as well as for those countries where no response was obtained, the table relies on background research conducted by the OECD. In particular, information from Van der Vlies (2020[3]) was used as a starting point for further enquiries.

3 Pedagogical approaches, curricula and assessments for digital education

This chapter describes recent developments concerning the use of digital education technologies in education institutions and the adaptation of pedagogical processes to the digital age. It highlights some of the challenges that are limiting the take-up of digital education technologies, including their insufficient alignment to educators' needs and a lack of information on their efficacy. Public authorities can encourage the effective use of digital technologies by supporting education institutions in selecting digital tools, by facilitating their interaction with the EdTech sector, by promoting peer-learning and by spreading good practices across education systems.

Introduction

The COVID-19 pandemic has accelerated the use of digital technologies in education systems. Despite the abruptness and difficulty of the transition, many educators and learners across OECD countries managed to adapt to the new situation, temporarily moving to online delivery and remote education through digital technologies. The additional knowledge and capacity built regarding the use of digital learning tools during the pandemic could provide the basis for a significant expansion of digital education in the future (OECD, 2021[1]; Matear, 2021[2]; Martin, 2020[3]).

Much of the promise of digital education technologies rests on their potential to enable more individualised forms of instruction and assessment that are responsive to students' needs, abilities and learning styles. Emerging technologies also offer educators the possibility to promote student engagement and make their own work more efficient (Ganimian, Vegas and Hess, 2020[4]). Yet, data from PISA and the Teaching and Learning International Survey (TALIS) available from prior to the COVID-19 pandemic suggest that the actual use of education technologies remains, in many cases, far removed from this "possibility frontier". Although an increasing number of educators and students make use of digital tools, fewer seem to embrace them as a vehicle to engage in a more individualised, efficient or responsive pedagogy (OECD, 2020[5]; Whitmer et al., 2016[6]). Uptake of digital technologies for teaching has likely accelerated further throughout the pandemic. However, effective uses of these technologies require better guidance and policies at the system level.

This chapter focuses on the levers that policy makers have at their disposal to promote more effective uses of digital technologies for teaching and learning. It considers policies to support the development and selection of suitable digital education technologies as well as the dissemination of effective pedagogical practices involving digital tools. It also examines the adaptation of curricula and assessment frameworks and strategies to overcome barriers that have so far limited the take-up and effective use of digital technologies for teaching and learning. In the absence of more recent internationally comparable data on the use of digital technologies in education, this chapter relies on data from the 2018 waves of PISA and TALIS. However, the pandemic has likely triggered substantial changes in the frequency and modalities of digital technologies in teaching and learning. PISA 2022 and TALIS 2024 will provide interesting insights into these developments.

The digitalisation of curricula, pedagogy and assessments raises several issues for policy makers which this chapter seeks to address by taking stock of the available evidence and presenting promising approaches observed in OECD and EU countries. In particular, it examines some key questions for policy makers:

- How can educators be supported to select digital education technologies in line with their students' needs and to successfully integrate them into their teaching?
- How can good practices and innovations concerning the use of digital education technologies be captured and spread systematically?
- Do curricula leverage the potential of digitalisation and support educators in integrating digital technologies effectively into their teaching?
- Are assessment frameworks adapted to the use of digital assessment methods and suited to assess learners' acquisition of digital skills?

Recent developments and current challenges

Whether digital education technologies can deliver on their potential to enhance teaching and learning depends on their adequacy, take-up and effective use. The following sections summarise the empirical evidence of the use of digital education technologies, prior to the COVID-19 pandemic, during the closure of education institutions and after the return to in-person teaching. This is followed by a discussion of the key challenges that limit the effective use of digital education technologies and the ways in which curricula and assessment frameworks may need to be adapted in response.

Information on the availability, take-up and effective use of digital education technologies remains limited, but new evidence sources are emerging

Administrative data collections have been slow to keep up with the technological progress in education institutions, and there are few information collections on the take-up and use of digital education technologies at the institutional or national level. Nevertheless, the availability of comparative data has steadily improved. Starting in 2000, successive waves of the OECD Programme for International Student Assessment (PISA) have surveyed students, teachers and principals to assess the access to and use of ICT by 15-year-old students in and outside of school. Similarly, multiple waves of the OECD Teaching and Learning International Survey (TALIS) since 2008 have provided information on teachers' confidence in and their use of ICT as part of their teaching practices. Surveys administered for the Trends in International Mathematics and Science Study (TIMSS) and the Progress in International Reading Literacy Study (PIRLS) provide additional and complementary information on the frequency with which teachers use computers in primary schools.

While the first waves of international data collections on ICT in education mostly focused on access to hardware, more recent waves of PISA and of the International Computer and Information Literacy Study (ICILS) (Fraillon, Schulz and Ainley, 2013[7]) have advanced understanding of the types of software and digital learning resources that teachers use, and with what frequency. Nevertheless, international comparative data on the quality and accessibility of these resources and, most importantly, on teachers' pedagogical practices related to digital technologies remain to be further developed. The 2022 wave of PISA, as well as the 2024 wave of TALIS, promise to further expand this evidence base and document in greater detail how teachers, schools and education systems integrate digital technologies into pedagogical practices and learning environments since the pandemic (OECD, 2019[8]).

To what extent are digital technologies being used in instruction?

Digital technologies already support students' everyday learning and different aspects of the teaching process in multiple ways. These include educators' use of online platforms to search, share and adapt learning materials to prepare their lessons, a growing recourse to interactive white boards and presentation software to deliver traditional whole-of-class instruction, the use of software to track students' progress, organise and assign tasks and administer assessments, as well as interactive learning software and games, tutorial or practice tools to support small group activities or individualised learning in and outside the classroom.

One way to classify different digital learning technologies is by the level of control they assume over specific aspects of the learning process. This can range from serving a purely assistive function (i.e. supplying the educator with supportive information) to higher degrees of automation where educators assume a monitoring role and cede control over some aspects of the learning process (e.g. with modern tutoring systems). Table 3.1 provides examples of technologies in the area of personalised learning based on this classification. While personalised learning technology was largely absent from OECD countries' classrooms until recent years and highly automated technologies are still rarely seen in schools, the use of technology with intermediate forms of automation is on the rise. Even though no comparative data are available, the use of technology that assists teachers and describes learners' behaviour (Level 1) has become the standard among OECD school systems that are most advanced in the integration of IT (information technology) solutions (Molenaar, 2021[9]).

Table 3.1. Personalised learning technologies with different degrees of teacher control

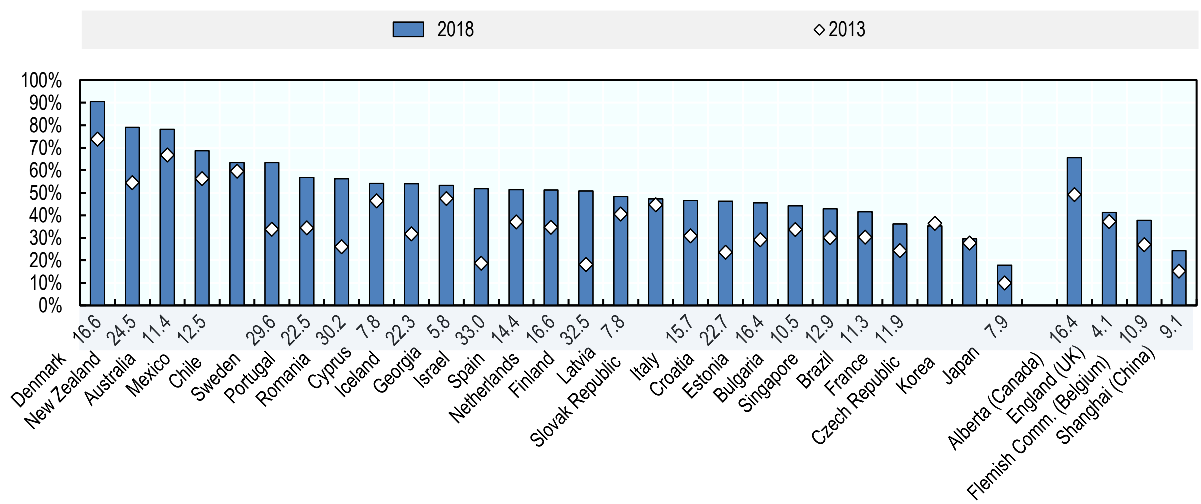
Level of automation	Distribution of control and functions of technology	Examples of technologies
Level 0 (Teacher only)	Teacher controls	Technologies that are fully teacher controlled, without organising function
Level 1 (Teacher assistance)	Teacher has full control; Technology provides supportive information (supporting teachers, describing and mirroring learners' behaviour)	Electronic learning environments; Learning management systems; Teacher dashboards; AI-based analyses of classroom dynamics (e.g. sensors to analyse student engagement)
Level 2 (Partial automation)	Teacher monitors technology; Technology controls specific tasks (describing, diagnosing, advising and in specific cases enacting actions)	Programmes (e.g. Snappet (2023[10])) that select problems adjusted to the needs of individual students or provides feedback on their solutions; Chat bots providing feedback
Level 3 (Conditional automation)	Teacher monitors incidentally, but can resume control at all time; Technology signals when teacher control is needed and controls broader set of tasks	Programmes (e.g. Cognitive Tutor (Pane et al., 2014[11])) that select problems and give feedback on each problem-solving step as students' progress and notify teachers when they need to step in
Level 4 (High automation)	Teacher control and monitoring is not required for specific tasks; Technology requests teacher control and controls most tasks automatically	Intelligent tutoring systems (e.g. MathSpring (Arroyo et al., 2014[12])) that guide the learner in selecting learning goals and offer personalised instruction, practice opportunities and feedback
Level 5 (Full automation)	Technology controls all tasks automatically	Some language learning technologies are evolving in this direction (e.g. Alelo (2023[13]))

Source: Molenaar (2021[9]), "Personalisation of learning: Towards hybrid human-AI learning technologies", in *OECD Digital Education Outlook 2021: Pushing the Frontiers with Artificial Intelligence, Blockchain and Robots*, https://doi.org/10.1787/2cc25e37-en.

Despite rapid advances in EdTech, the use of digital technologies (even of the purely assistive type described above) is far from universal in OECD countries. According to teachers' reports in the OECD TALIS survey, only 53% of lower secondary teachers reported frequently letting students use ICT for projects or class work in 2018 (OECD, 2019[14]). Nevertheless, this constitutes a significant rise from just 38% of teachers who reported doing so five years earlier in 2013 (OECD, 2020[15]). Between 2013 and 2018, the share of teachers that let students use ICT to learn has risen in 28 of 31 countries and economies and it has likely spread further during the COVID-19 pandemic (see Figure 3.1). The largest increases in technology use were observed in Finland, Israel, Romania and Sweden, where the percentage of teachers reporting that they frequently or always let students use ICT for projects or class work has increased by 30 percentage points or more. While there is no international comparative data available from more recent years, students' use of digital technologies in classrooms has likely risen drastically during and after the COVID-19 pandemic.

Figure 3.1. Change in teachers letting students use ICT for projects or class work from 2013 to 2018

Percentage of lower secondary teachers who "frequently" or "always" let students use ICT for projects or class work in a typical class



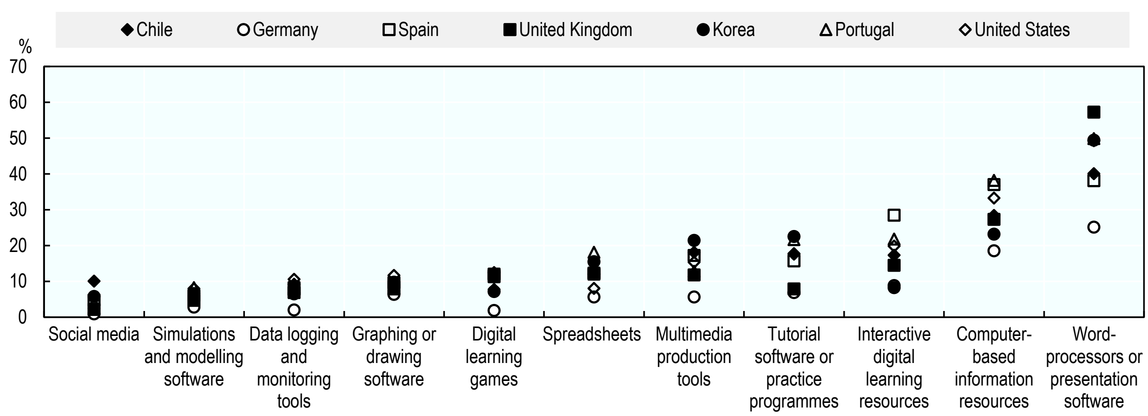
Notes: These data are reported by teachers and refer to a randomly chosen class they currently teach from their weekly timetable; Only countries and economies with available data for 2013 and 2018 are shown. Countries and economies are ranked in descending order of the prevalence of teachers letting students use ICT for projects or class work in 2018.
Source: OECD (2019[14]), TALIS 2018 Results (Volume I): Teachers and School Leaders as Lifelong Learners, https://doi.org/10.1787/1d0bc92a-en, Table I.2.4.

In PISA 2018, students in countries that administered the optional ICT familiarity questionnaire were asked which digital technologies were available to them at school and whether they used them. The information has not been analysed at the international level yet but research using PISA data from New Zealand suggests that, while the availability of digital devices at school was generally high, not all of them were used in equal measure. Nearly all students had access to an internet-connected computer (97%), as well as a data projector (88%) and about half had access to interactive whiteboards and tablets. While at least two-thirds of students with access to internet-connected computers and laptops at school reported using them, tablets and interactive whiteboards were used by only half of those who could access them (i.e. about a quarter overall). This gap between access and take-up suggests a significant degree of under-usage of available technologies (Sutcliffe, 2021[16]), thereby undermining schools' capacity to seize the full potential of digital technologies in education. These findings are consistent with school leaders' reports that teachers lacking capacity and resources to integrate digital devices into teaching might inhibit the effective use of digital tools in classrooms even where adequate digital infrastructure is available (OECD, 2020[17]).

Seven OECD countries participating in PISA 2018 (Chile, Germany, Korea, Portugal, Spain, the United Kingdom and the United States) administered optional ICT-related questions to teachers of 15-year-old students, asking them how frequently they used specific ICT tools during the year. In 2018, the most frequently used digital tools included word-processors or presentation software (used by 44% of teachers in most lessons), followed by computer-based information resources, such as websites and wikis (29%). Fewer teachers reported frequently using interactive digital learning resources (17%) and tutorial software or practice programmes (16%) in their lessons. Less than 10% of teacher respondents frequently used digital learning games, simulations or modelling software (see Figure 3.2). International comparative evidence on the use of digital learning technologies for specific student groups is even more limited. Most international data collections, for example, do not cover the use of assistive technologies to enhance learning for students with special education needs (e.g. text to speech or speech recognition software). The take-up of different types of digital tools used for teaching and learning has changed significantly during the COVID-19 pandemic, which called for innovative uses of new digital technologies to maintain education continuity during school closures. Data from the 2022 PISA round will provide interesting insights on how the pandemic has changed the use of digital technologies after the return to in-person teaching.

Figure 3.2. Teachers' use of digital tools (2018)

Proportion of 15-year-old students whose teachers report using digital tools "in every or almost every lesson" or "in most lessons"



Notes: Digital tools are ordered in order of their frequency of use; Word-processors or presentation software incl. e.g. Microsoft Word ® and Microsoft PowerPoint ®; Spreadsheets incl. e.g. Microsoft Excel®; Multimedia production tools incl. e.g. media capture and editing or web production; Computer-based information resources incl. e.g. websites, wikis and encyclopaedia.
Source: Adapted from OECD (2018[18]), PISA Database 2018, https://www.oecd.org/pisa/data/2018database/

StatLink https://stat.link/4hi0uo

In the Vocational Education and Training (VET) sector, some technologies have been widely used already prior to the pandemic. In the six OECD countries and regions with available data from the 2018 TALIS survey[1], 74% of upper secondary VET teachers reported using digital technology with their students, compared to 66% of general education teachers (OECD, 2021[19]). Data from the European Commission's Self-reflection on Effective Learning by Fostering the use of Innovative Educational technologies (SELFIE) tool further suggests that VET teachers are slightly more likely than general education teachers to report using digital tools for teaching (OECD, 2021[19]; Hippe, Pokropek and Costa, 2021[20]). Although comparative international data on the use of specific digital education technologies are limited, examples for the use of advanced technologies in VET include the following (OECD, 2021[19]):

- **Use of robotics in welding training**: VET teachers use welding robots to introduce students to automatic welding. Teachers show how welding robotic arms can be programmed using specialised software and demonstrate how car parts, metallic structures or industrial equipment can be welded using this technology. Automated welding can be more efficient than manual welding for repetitive tasks. In automated contexts the welder's role involves handling some of the parts to be welded, programming, operating and troubleshooting the welding robot, and inspecting the quality of the final product (Lincoln Electric, 2022[21]).
- **Use of simulators in the logistics and transportation sector**: In the logistics sector, students can use simulators to learn how to drive a truck or operate a loader vehicle facing real-life issues.

For instance, the company Simula Games produced "Truck & Logistics Simulator", a vehicle simulation game where users perform logistics tasks from beginning to end. Users can operate more than 20 different vehicles to perform complex loading tasks and deliver a variety of cargo directly to customers (Simula Games, 2022[22]).

- **Use of simulators and virtual reality (VR) in the health sector**: Labster Labs promotes scientific learning by making online education modules available to VET teachers using desktop simulations and Virtual Reality (VR). These labs give students the chance to implement their own experiments in a simulated environment. Through desktop simulations, they can experiment with and understand a wide range of theoretical concepts in biology, chemistry, physiology and anatomy. Labster has produced dozens of virtual biotechnology and biochemistry labs with important applications for medical sciences (Labster, 2022[23]).

In higher education, the majority of teaching before the COVID-19 pandemic was based on traditional face-to-face delivery, often complemented by some digital enhancements. For instance, in the **United States** – one of the more digitally advanced higher education systems – less than half of the instructors (46%) reported having taught a course online prior to the COVID-19 pandemic[2] (Jaschik and Lederman, 2019[24]). In **New Zealand**, over the period 2010-2014, 80% of degree-level teaching had a digital component (up from 70% in the 2005-2009 period), but only 10% was fully online[3] (Guiney, 2016[25]).

Prior to the pandemic, the slow adoption of digital technologies in many higher education institutions was related to high levels of autonomy concerning curriculum design, course delivery and assessment across academic departments and individual educators. Individual academics' reluctance to adopt innovative methods of teaching using new technologies has also been linked to the fact that teaching is often considered a lower prestige activity in academia, relative to research. As a result, many academics spend discretionary time enhancing their research, rather than making time-consuming investments into using digital technologies to improve their teaching resources, assessments, and pedagogical approach.

One feature of digitalisation that has had very high take-up in higher education across the OECD is the use of learning management systems (LMS) (Tømte et al., 2019[26]; Brown, Millichap and Dehoney, 2015[27]). LMS support higher education delivery by enabling instructors to communicate course content to their classes, track students' progress, communicate with individual students and conduct assessment (Ifenthaler, 2012[28]). However, instructors' use of LMS features remains relatively narrow, as described in the following section.

How are digital technologies integrated into teaching and learning processes?

As described in Chapter 1, experimental and quasi-experimental studies suggest that increasing students' access to devices like laptops or tablets alone has little to no positive effect on their education outcomes (Bulman and Fairlie, 2016[29]; Minea-Pic, n.d.[30]). What matters for student learning is how learning technologies are adapted to a given context and integrated into the learning process. Most digital education technologies can be used in a number of different ways, with varying effects on the quality of teaching and learning. It is therefore important to consider not only which digital technologies educators use in the classroom, but also how they use them.

Results from PISA 2018 show significant differences in both the frequency with which digital devices are used in lessons and who controls them, which in turn appears to be associated with student performance. Across OECD countries with available data, teacher-led uses of digital devices tend to be associated with higher student performance than student-led uses of digital devices, even after accounting for students and schools' socio-economic background, school digital infrastructure or students' perceived digital competence (OECD, 2022[31]; OECD, 2021[32]).

Comparative data from international surveys do not yield the kind of granular information that would shed light on how teachers actually employ digital technologies and whether they use them in innovative ways.

Yet, evidence from video observations conducted for the TALIS Video Study suggests that – at least prior to the COVID-19 crisis – relatively few of the participating teachers used technology in innovative ways and most did not allow students to make extensive use of technology in the classroom (OECD, 2020[5]).

The TALIS Video Study collected evidence from about 700 secondary school teachers and 17 500 students in eight countries and economies who were each videotaped delivering two secondary school mathematics lessons. The video material was coded following standardised protocols and complemented with the lessons' teaching materials. As can be seen in Table 3.2. , most teachers in the study made some use of technology, but primarily used it for communication purposes, for example, PowerPoint slides, overhead projectors or document visualisers (OECD, 2020[5]).

Few teachers made use of technology to promote students' conceptual understanding and to aid the analysis, evaluation and creation of their work. Such uses of technology were observed in 21% of classes in England [UK], in 11% of classes in Madrid [Spain] and 10% of classes in Germany (OECD, 2020, p. 291[5]). Technology was also rarely used in teaching materials, to develop students' understanding of mathematical concepts and relationships, to help them make and test conjectures, or to look for patterns. Nevertheless, the TALIS Video Study found that one in five teachers in Germany and one in ten teachers in Madrid (Spain) used technology in teaching materials to make computation or graphing more efficient, to reinforce teaching (e.g. internet instructional videos), for practice, assessment or feedback to the teacher (e.g. online practice problems, quizzes and/or reporting), or to check the correctness of their solutions (e.g. using a calculator) (OECD, 2020[5]).

Table 3.2. Evidence on the use of technology from the OECD TALIS Video Study

Percentage of classrooms that made use of technology for each purpose, in participating countries

Country	Number of classrooms	Percentage of Classrooms with Highest Rating for			
		No Technology used	Communication only	Communication + limited conceptual understanding	Communication + conceptual understanding
B-M-V (Chile)	98	42.9	43.9	8.2	5.1
Colombia	83	50.6	22.9	12.0	14.5
England (UK)	85	0.0	55.3	23.5	21.2
Germany*	50	24.0	48.0	18.0	10.0
K-S-T (Japan)	89	78.7	5.6	3.4	12.4
Madrid (Spain)	85	47.1	31.8	10.6	10.6
Mexico	103	58.3	14.6	7.8	19.4
Shanghai (China)	85	5.9	70.6	15.3	8.2

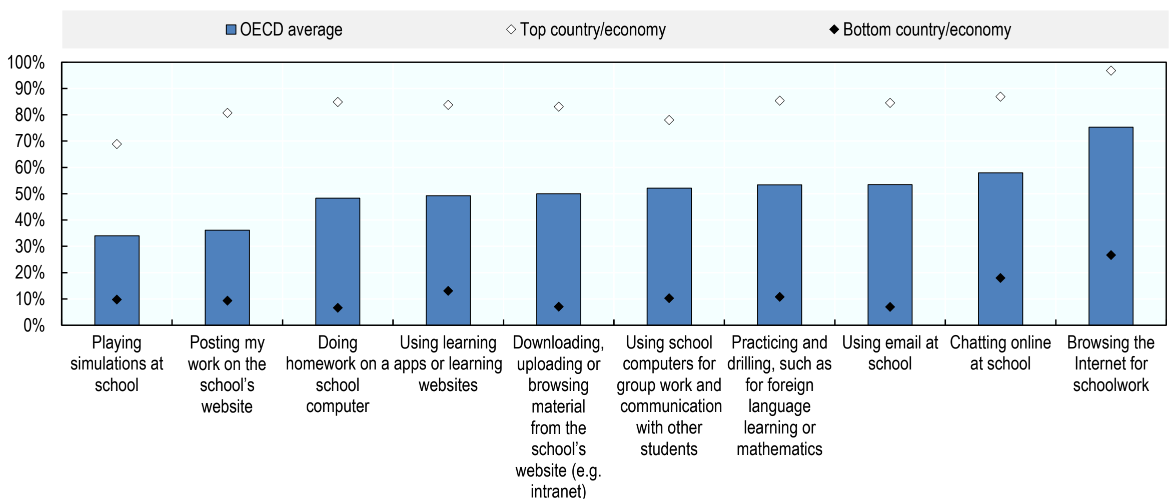
Note: The table summarises classrooms' "best" use of technology by tabulating those classrooms whose highest rating over segments, lessons and observers was a 1 (no technology used), 2 (technology used for communication only), 3 (technology used for communication and limited conceptual understanding) or a 4 (technology used for communication and conceptual understanding).
*Germany refers to a convenience sample of volunteer schools.
Source: Reproduced from OECD (2020[5]), *Global Teaching InSights: A Video Study of Teaching*, https://doi.org/10.1787/20d6f36b-en, Table 5.1.

A survey conducted as part of the Digital Competences for Language Teachers project in 2019/20 provides additional information on the use of digital technologies by language teachers in European schools and higher education institutions. Although the sample of teachers was not representative, responses suggest that educators engaging in computer assisted language teaching focus on content-based, task-based and collaborative learning approaches. Game-based and project-based learning approaches were more frequently used as auxiliary teaching methods. A lack of necessary infrastructure was not frequently cited as a factor limiting the use of education technology. However, around 20% of teachers reported that a lack of training limited their use of technology for inquiry-based and problem-based language learning, collaborative knowledge building or methodologically eclectic approaches to teaching (Fominykh et al., 2019, p. 26[33]).

PISA 2018 provides some additional insight into teachers' and students' use of digital devices in the countries that administered the optional ICT familiarity questionnaire. Students reported for how long they used the Internet at school on a typical day and what type of school activities they used digital devices for (OECD, 2021[32]). On average across the OECD, students most frequently reported that they regularly use digital devices at school to browse the Internet for schoolwork (75%), to chat (58%) and to use email (54%) (see Figure 3.3). Around half of students reported using devices for learning-related activities such as practicing and drilling, using school computers for group work, downloading learning material, using learning apps or doing homework (OECD, 2021[32]).

Figure 3.3. Frequency of activities on digital devices in school

Percentage of students who reported using digital devices for the following activities at school, at least once a month, OECD average



Note: Items are ranked in ascending order of the percentage of students within OECD average.
Source: OECD (2021[32]), *21st-Century Readers: Developing Literacy Skills in a Digital World*, https://doi.org/10.1787/a83d84cb-en, Figure 6.12.

As can be seen in Figure 3.3, there is significant variation in how students use digital devices at school across OECD countries. For example, more than 90% of students in Japan and 70% in Korea reported that they never did homework on a school computer, compared to only 22% of students in the United States and 15% in Denmark (OECD, 2021[32]). On average across the OECD, the frequency with which students use digital devices for most of the activities described above is negatively correlated with their reading performance (with the exception of browsing the Internet for schoolwork) but there is significant variation in these relationships across countries. Furthermore, in most OECD countries, the amount of time students spend using digital devices for schoolwork was negatively associated with their reading performance after accounting for students' and schools' socio-economic status. However, there are a number of exceptions where this relationship is positive – notably Australia, Denmark, Korea, New Zealand, and the United States (OECD, 2021[32]).

These findings appear to suggest that some learning activities could be better done without digital devices and that the use of digital devices might, in some cases, displace more beneficial instructional activities (Falck, Mang and Woessmann, 2018[34]). At the same time, the heterogeneity across countries suggests that the way in which students use digital devices in the learning process may matter more for their outcomes than whether and for how long students use them (OECD, 2021[32]). It is also important to bear in mind that negative associations between students' use of digital devices and their reading performance may reflect a selection bias and that students undertaking these activities may not be representative. Although doing homework on a school computer is negatively associated with reading performance, for example, students who spend more time doing homework at school may be the ones facing greater difficulties or requiring the help of teachers (OECD, 2021[32]).

In addition to general surveys investigating teachers' use of digital education technology across a range of devices and software, several evaluations have studied teachers' use of specific software or digital devices. These studies explore how teachers interact with technology as well as the extent to which they exploit the full range of functionalities offered by specific devices. For example, although the take-up of LMS in HEIs across the OECD is very high (Tømte et al., 2019[26]), evaluations of LMS show significant variation in the way educators in higher education integrate the software in their instruction. While the use of LMS has the potential to transform teaching, LMS also enable educators to manage the administrative tasks of traditional, face-to-face instruction. LMS usage studies in higher education suggest, however, that many academics use LMS primarily to manage the administration of classes, rather than using them to modify and enhance their delivery and instructional pedagogy (Damşa et al., 2015[35]).

A study of the Blackboard Learn LMS covered 70 000 higher education courses at nearly 1 000 HEIs in 2016 and found that the majority (53%) of users exploited only a fraction of its capabilities, using it in a supplemental way, e.g. for posting grades and as a repository for digital course content. Only 2% of users exploited the full functionality of the tool in a holistic, transformative way (Whitmer et al., 2016[6]). Another survey of higher education teaching staff in the United States found that – despite a high level of adoption – just 41% used the more advanced features of LMS, e.g. "to promote interaction outside the classroom" (Brown, Millichap and Dehoney, 2015[27]). Likewise, a 2016 study of LMS uses in 2 500 courses in a single large US research university, found that the majority of courses used the system for announcements, delivery of content and for recording grades while functions like blogs, assessment, and discussion boards were used in less than a third of the courses (Machajewski et al., 2018[36]). Educators with a disposition for student-centred pedagogy were more likely to exploit the full range of the technology's features to engage students and encourage them to manipulate, question, reflect and create knowledge products (Kirkwood and Price, 2014[37]).

Uses of digital learning technologies that are more demanding of digital capacity and pedagogical transformation – such as the use of digital technologies for collaborative learning, personalised learning and adaptive assessment, learning analytics, or simulation-based learning – appear to be even more limited (Martin et al., 2020[38]). Despite evidence that learning analytics has the potential to improve learning support and teaching, take up of learning analytics in European higher education is low, with its use confined to educators working with leaning analytics in isolation. Learning analytics is mainly seen by HEI managers as a tool for teaching management, with the consequence that its potential to improve learning is largely unrealised (Tsai et al., 2020[39]; Viberg et al., 2018[40]). Although simulation-based learning has been shown to have a large positive effect on learning of complex skills in a range of fields (Chernikova et al., 2020[41]; Ledger, 2019[42]) its use is likewise limited in scope.

Several challenges tend to limit the take-up and effective use of digital education technologies

Digital education technologies may be maladapted to educators' needs and priorities, making their use unattractive

The actual use of digital technologies for teaching and learning often falls short of their full potential. As discussed above, in-depth studies of individual learning technologies have shown, for example, that users of LMS only take advantage of a narrow range of their functionality to supplement their traditional teaching practices, rather than transform their pedagogical approach (Damşa et al., 2015[35]; Whitmer et al., 2016[6]; Bond et al., 2020[43]; Price and Kirkwood, 2011[44]). This is in part explained by educators' lack of training on the use of digital education technology. As will be described in more detail in Chapter 7, which focuses on capacity building, surveys of educators and school leaders expose significant deficits in their preparedness to support digital learning (OECD, 2022[45]).

Besides the lack of capacity, another factor that may explain the under-use of available digital technologies in education institutions is that they are insufficiently adapted to teachers' needs and priorities. The development of digital education technologies does not always involve the expertise of educators and other stakeholders, although some notable exceptions are presented further below. As a result, teachers may find it difficult to integrate them into their daily teaching practice or feel like they do not respond to their needs. Education institutions and individual educators may also struggle to select the most suitable or effective technologies from an ever-expanding pool of suppliers. Finally, the effective use of education technologies may be undermined by their lack of compatibility and interoperability with each other (OECD, 2021[46]). Anecdotal evidence suggests that both student and educators can become frustrated working with a multitude of tools or platforms that serve overlapping purposes and fail to communicate with one another.

Administrators and educators may lack confidence in the efficacy of digital technologies and their own digital skills

Educators in most countries traditionally enjoy a high degree of autonomy over the pedagogical approaches they employ in the classroom. In the 2018 TALIS survey, 96% of lower secondary teachers across the OECD report that they have a high level of autonomy in selecting teaching methods (OECD, 2020[15]). Whether or not teachers make use of digital education technologies, provided that they are available, therefore largely depends on their confidence in the technologies' effectiveness as well as their perceived self-efficacy. Teachers who are not convinced of the effectiveness of digital education technologies or their ability to employ them are less likely to do so and are more likely to use conventional "chalk and talk" pedagogy (Gil-Flores, Rodríguez-Santero and Torres-Gordillo, 2017[47]). This is corroborated by evidence from ICILS, which shows that teachers who were confident about their own digital capability were more likely than their less confident colleagues to emphasise developing their own students' digital skills (Fraillon, Schulz and Ainley, 2013[7]).

The characteristics and profile of staff may also partially determine their viewpoints on digital technologies. Some studies have found that take-up and effective use of digital technologies by higher education educators varies by age, role and discipline. For example, in Spain, higher levels of digital competence were found among younger academics, those with lighter teaching loads and among educators in technical fields (Cabero-Almenara et al., 2021[48]). In light of the advanced age profile in European higher education systems – where one-quarter of academics are over the age of 55 (OECD, 2019[49]) – some higher education systems with especially advanced age profiles are not well-placed to make wide use of the education potential of digital technologies.

Institutions' and educators' autonomy disperse decisions about the use of digital education technologies, limiting the steering role of central authorities

Schools in most European countries have significant leeway in shaping the way their educators deploy some types of digital resources. The procurement of connectivity infrastructure, cloud services and other resources that are best provided at scale tends to be relatively centralised. By contrast, schools in many systems are responsible for selecting, purchasing and maintaining other types of digital resources (European Commission, 2013[50]), as well as designing guidelines, training and supports for their teachers, and assessing and evaluating their use of digital technologies (OECD, 2019[8]). Likewise, in higher education, institutions, faculties, departments and individual educators often enjoy wide-ranging autonomy in their decisions about the selection and use of digital education technologies. This high degree of autonomy is testament to the faith placed in educators' professionalism and can be a powerful means to foster local innovation. In higher education institutions, for example, individual academics have used this opportunity to pursue their enthusiasm for innovation by developing chat bots (Bond et al., 2018[51]; Vijayakumar, Höhn and Schommer, 2019[52]) or using AI to enhance their teaching (Bates et al., 2020[53]; Bernacki, Vosicka and Utz, 2020[54]; Page and Gehlbach, 2017[55]).

Despite the lack of direct control, however, regulatory frameworks, policies and guidelines formulated at the system-level can shape the use of digital education technologies in school classrooms and university lecture halls. This includes restrictions governing the use of digital resources for instruction, such as obtaining permission from legal guardians or principals, the need to supervise students, safety and privacy regulations, access of specific digital functionalities and the Internet, or limits on the time students can spend using digital resources. Central authorities may also specify conditions under which digital technologies should not be used, notably with regard to equity issues in the classroom, for example if some students do not have digital resources at home or lack the basic ICT skills necessary to use them (OECD, 2019[8]).

The use of digital education technologies is not always reflected in curricula and assessment frameworks

Governments across the OECD recognise the importance of developing students' digital and data literacy to enable them to thrive in the 21st century (OECD, 2019[56]). Over the past decades, many OECD school systems have engaged in reforms to update their curricula to account for the digital skills, alongside other "21st century skills" in the domain of cognitive and meta-cognitive skills, social and emotional skills, media literacy and practical skills (OECD, 2020[57]; Hill, 2022[58]). The OECD's Education 2030 Policy Questionnaire on Curriculum Redesign showed that curricular reforms across OECD countries have sought to integrate skills and content related to digital technologies. This was carried out either by creating new subjects (as was the case in Australia, British Columbia (Canada), Denmark, Ireland, Japan, New Zealand, Norway and Portugal) or by introducing new content, themes or competencies within the existing curriculum (as was the case in 20 OECD countries) (OECD, 2020[57]).

Traditional curricula do not lend themselves to the new ways of teaching and learning facilitated by digital technologies. Most 20th century curricula in school education were designed as static, linear and standardised, assuming a uniform progression of students and allowing for accountability through standardised assessments. Digital education technologies promise to enable more differentiated and individualised forms of teaching that adapt to differences in students' prior knowledge, abilities and learning styles. To optimally support this way of teaching, curricula have to be flexible and dynamic rather than static and to allow for a variety of non-linear learning pathways (OECD, 2019[56]). Many OECD countries have also taken steps to digitalise their curricula and to align them with digital education materials to support teachers' and students' use of digital education technologies (OECD, 2020[57]).

As education systems adapt their curricula to digital teaching, assessment practices may need to be adapted to ensure that they remain fit for purpose (OECD, 2013[59]). In addition to reflecting new skills – including digital competencies – that students are expected to acquire, the use of digital technologies could also enhance assessment practices for other learning objectives. Digital technologies can empower teachers to exercise greater autonomy in the design of learning environments and engage in more granular, individualised forms of assessment (Paniagua and Istance, 2018[60]). At the same time, adaptive digital assessment methods can help teachers to better identify and support students who have fallen behind (Ganimian, Vegas and Hess, 2020[4]) and game-based assessments building on smart technologies have shown promise in assessing skills that cannot be easily measured by traditional (paper-and-pencil or computer-based) tests, including higher-order, emotional and behavioural skills (OECD, 2021[46]). The

OECD is currently developing a Platform for Innovative Learning Assessments (PILA), which can serve as a tool to teachers to assess 21st century competences through online tasks and is described in more detail in Box 3.1 below.

Box 3.1. The OECD Platform for Innovative Learning Assessment (PILA)

The OECD is currently piloting its open-source online learning and assessment tool PILA. The platform offers ways to practice and test 21st century skills such as computational problem solving, systems thinking or collaboration which are rarely reflected in traditional curricula and assessment methods. The platform hosts a broad range of digital tasks on these topics which are developed by international education experts. Teachers can select appropriate tasks for their students to solve during class time or at home. They can also use PILA to create engaging assignments for students which offer them with valuable information on their students' thinking and learning skills. Apart from providing ways to practice and assess new skills, PILA also offers real-time feedback to educators on their students' strengths and weaknesses.

Source: (OECD, n.d.[61]), *PILA*, https://pilaproject.org/ (accessed on 23 May 2023).

Promising approaches for the effective digitalisation of curricula, pedagogy and assessments

Governments can support the development, selection and integration of appropriate and impactful digital education technologies into teaching and learning in multiple ways. This section considers policies that show promise in this area, such as strengthening interactions between educators and the EdTech sector; supporting the selection of technologies that are suited to educators' needs; spreading good digital teaching practices and adapting curricula and assessment frameworks for the digital age. Other important policy levers to support the effective use of digital education technologies are addressed in other chapters. For example, policies that support the digital capacity of students and other actors in the education ecosystem are the focus of Chapter 7. Guidance and regulatory frameworks for digital education are the subject of Chapter 4.

Support education institutions and educators in selecting digital education technologies

Strategies supporting education institutions and educators to make informed choices are an important part of ensuring the effective use of digital education technologies. Institutions and educators are expected to identify, assess and select digital resources that best fit their learning objectives, context and pedagogical approach from a wealth of available tools and providers. In some cases, this may even require them to create new digital resources themselves. In addition, education institutions and educators need to manage and maintain digital resources, share them with their students and maintain up-to-date knowledge regarding the potential risks involved in sensitive digital content and copyrights (OECD, 2019[8]; Redecker, 2017[62]).

The digitalisation of teaching and learning involves organisational change and high costs for institutions, meaning that they can benefit from the advice and experience of others. Governments might help education institutions to overcome these barriers by creating intermediary organisations which facilitate transactions between education institutions and chosen EdTech providers as well as mechanisms to certify technologies or providers. This way, governments can reconcile institutional autonomy in the selection of education technologies with some degree of quality assurance and accountability on public spending. In this context, National Research and Education Networks (NRENs) and co-operatives are ways in which countries have centralised information on resources and effective technologies for educators and institutions. For instance:

- In the **United Kingdom**, the NREN Joint Information Systems Committee creates learning resources for its members, covering VET as well as higher education. It also publishes case studies and analytical reports and provides guidance resources and consultancy services on topics such as learning analytics, assessment, learning management systems and change management. As a membership organisation, it collates “member stories” in which member institutions describe their digital education projects and draw attention to potential pitfalls (JISC, nd[63]).
- Also in the **United Kingdom**, the British Educational Suppliers Association (BESA) serves as the trade body for the education industry. In association with the UK Department for Education, BESA has created “LendED”, a marketplace where teachers and school leaders can find, review, test and purchase close to 300 EdTech products from more than 100 suppliers for purposes such as assessment, online safety, or management. BESA staff check each potential supplier for their reliability and quality before highlighting their products. Each customer can request a trial of the product before purchasing, and a peer review system is widely used, providing feedback to both customers and suppliers on the product’s usefulness. That feedback helps to ensure that suppliers are influenced by the needs of educators, education managers and institutions (British Educational Suppliers Association, nd[64]; LendED, 2022[65]; OECD, 2021[1]).
- In the **Netherlands**, the NREN SURF helps member institutions meet the challenges they face as they manage and expand their digital learning environments, including the approach to organisation of learning, assessment, management and use of student information, managing teaching materials and learning analytics. SURF conducts a biennial survey of its members to monitor how they are structuring their learning environments and advises members on best practice. Institutions seeking advice are connected to SURF’s network of experts. SURF also works with education technology providers to ensure that they are responsive to the needs of faculty and students, and that the services and tools they offer are grounded in education research (SURF, nd[66]; OECD, 2021[1]).

Create institutions and procedures that strengthen educators’ interactions with the EdTech sector and their role in the development, testing and selection of technologies

For digital education technologies to have a meaningful, positive impact on classroom practices, they need to be user-friendly and designed with the needs of education institutions, educators and students in mind. Accordingly, policy makers should promote educators’ involvement in the development of digital education technologies during the R&D process. This is a core tenet of user-driven innovation, which places the final user of a particular product or service at the core of the innovation process, for example by engaging educators, learners and staff in the analysis of a specific education problem and the design of possible solutions (European Commission, 2020[67]). Research on cutting edge assistive technologies has equally underlined the importance of involving students and stakeholders in the design of tools as well as the need for developers to consider affordability as a key element in their development (Good, 2021[68]).

Most digital education technologies are best understood as socio-technical systems that complement and enhance, rather than replace, the work of teachers and their interactions with students (Molenaar, 2021[9]). The adoption and effective use of education technology therefore requires some level of trust among educators, particularly when they are designed to let educators cede control over some aspects of the learning process (OECD, 2021[46]). Involving teachers, students and other end users as co-designers in the research and development process can help to foster their trust and facilitate the take-up of digital technologies at the implementation stage. It also helps to ensure the adequacy and usefulness and use of smart digital solutions and foster an understanding among developers of the social context in which digital education technologies would best be used (OECD, 2021[46]). Several successful examples of educators' engagement are presented below.

Education ministries can also encourage developers and players of the EdTech industry to co-create digital tools with teachers and students that are relevant, affordable, interoperable and easy to use (OECD, 2021[46]). Policy levers include, for example, procurement policies and other incentives shaping the development of publicly funded or purchased technologies, or interventions to ensure that some key developments in the field of education technology become or remain a public good (OECD, 2021[46]). Research and development projects in this area should harness public-private partnerships among government, technology researchers within universities and companies, and the education technology industry. Strong relationships between researchers, education institutions, governments and the EdTech sector would also help to clarify whether social and legal adjustments are required for the widespread adoption of promising technologies (OECD, 2021[46]).

There are several promising cases in which education institutions and educators have played a role in the design (improving, testing and piloting) of digital education technologies:

- The EDUCATE project, hosted by University College London in the **United Kingdom,** fosters the use of research evidence in the EdTech sector. Part-funded by the European Regional Development Fund (ERDF), the project works together with EdTech creators, educators, investors and policy makers to provide training to EdTech actors on using research to inform the ongoing development of their EdTech products to serve users effectively (OECD, 2021[46]; Cukurova, Luckin and Clark-Wilson, 2018[69]).[4]
- In **France**, a private-public partnership for innovation and AI (P2IA) was launched to provide primary school teachers with AI-based tools to support students in learning French and Mathematics. Teachers' feedback was integrated during the research and development phase of these tools (Jean and Gilger, 2022[70]).
- At Carnegie Mellon University (**United States**), the Simon Initiative set out to create a learning engineering ecosystem, providing a technological infrastructure and human support to enable faculty to use learning science research to improve their education practice. Based on a strong involvement of stakeholders, the initiative also aims to turn existing state of the art research into intelligent tools that are easy-to-learn and easy-to-use for all faculty (OECD, 2021[46]).[5]
- ECHOES is a technology-enhanced learning environment designed to scaffold the exploration and learning of social communication skills of autistic children with a developmental age of between four and seven years through a series of playful learning activities, some of which involve a virtual AI agent with whom the child can interact. Enabled by funding through the Economic and Social Research Council (ESRC), the Engineering and Physical Sciences Research Council (EPSRC) and the Teaching and Learning Research Programme (TLRP), the ECHOES project was hosted by the University College London (**United Kingdom**). In designing the virtual environment, the ECHOES team chose a participatory approach involving the widest range of stakeholders, including parents, carers, practitioners, teachers and, most importantly, autistic children (Good, 2021[68]; Frauenberger, Good and Keay-Bright, 2011[71]). A small scale (n=15) evaluation of ECHOES in 4 UK schools (without control group) has focused on its ability to support neurodiversity, i.e. the acceptance of neuro-atypical people. It found children engaged with the environment, progressed through different learning activities and positively changed their behaviour towards human partners whilst in the environment (Porayska-Pomsta et al., 2018[72]).
- In **Spain**, the National Institute of Educational Technologies and Teacher Training (INTEF), provides resources, training and funding for EdTech companies and education institutions to develop and implement digital learning tools. It maintains an education technology observatory and has developed partnerships with technology companies to develop resources for schools in Spain.

For example, the Samsung Smart School initiative is a partnership co-ordinated by Samsung Spain and INTEF for Spanish primary schools, where mobile devices are deployed in selected primary schools, and their usage and effect monitored in order to measure the impact of the technology and improve its effectiveness (INTEF, 2019[73]).

Some OECD countries have invested in platforms that allow educators to easily access online resources and adapt them to their needs:

- At the beginning of the COVID-19 pandemic in 2020, **France** expanded access to its 17 banks of digital resources for school education (*Banques de Ressources Numériques pour l'Ecole*, BRNE) to support teachers in adapting to online teaching and saving time on preparing digital lessons or materials. The BRNEs bring together thousands of learning and teaching resources aligned with the French curriculum, which can be used, modified and complemented by teachers to fit the needs of their students. The BRNE resources had been created several years before the COVID-19 crisis by publishers and EdTech companies. According to the BRNE contractors, the number of new registrations increased 5 to 15-fold during the COVID-19 pandemic and several hundred thousand teachers used LMS where the BRNE are deployed. School LMS attracted on average around 7.1 million visits with an average of 55 million pages viewed every day (about 80% of secondary schools have access to a LMS), although it is difficult to assess to what extent the digital materials were used and whether these trends will endure (Thillay, Jean and Vidal, 2020[74]).
- In **Ireland**, the National Forum for the Enhancement of Teaching and Learning in Higher Education has developed a National Resource Hub of Open Education Resources, all made available under a Creative Commons licence, allowing the resources to be widely used and adapted (National Forum, 2021[75]).
- The *Eduthek* in **Austria** serves as a digital platform to access education resources. As part of its 8-Point Plan for Digital Learning, launched in June 2020, the federal government aligned the digital resources that had been made available during the early stages of the COVID-19 pandemic with the school curriculum in order to facilitate schools' and teachers' selection of digital resources that are suited to their needs. The overall Plan aims to build on and sustain the advances in digital learning that have been made in the early stages of the pandemic and to further strengthen the capacity of schools to provide digital learning in the future (Federal Ministry of Education, 2020[76]; OECD, 2021[77]).

Spread good practice and innovations by facilitating peer learning

Given their limited ability to steer the use of digital tools directly in the context of institutional autonomy, governments can create incentives, communicate and promote dialogue to encourage education institutions to adapt their institutional strategies in ways that enhance digitalisation (van der Vlies, 2020[78]). Capacity building and training are an important dimension of this (see Chapter 7). Fostering professional collaboration is also important since it has been shown to be positively associated with teachers' sense of self-efficacy (OECD, 2020[15]) and their openness to using digital technologies in the classroom (Gil-Flores, Rodríguez-Santero and Torres-Gordillo, 2017[47]; OECD, 2022[45]). Other examples include the provision of guidelines or platforms that enable educators to share and provide feedback on digital teaching materials, as a way to spread innovation and good practices:

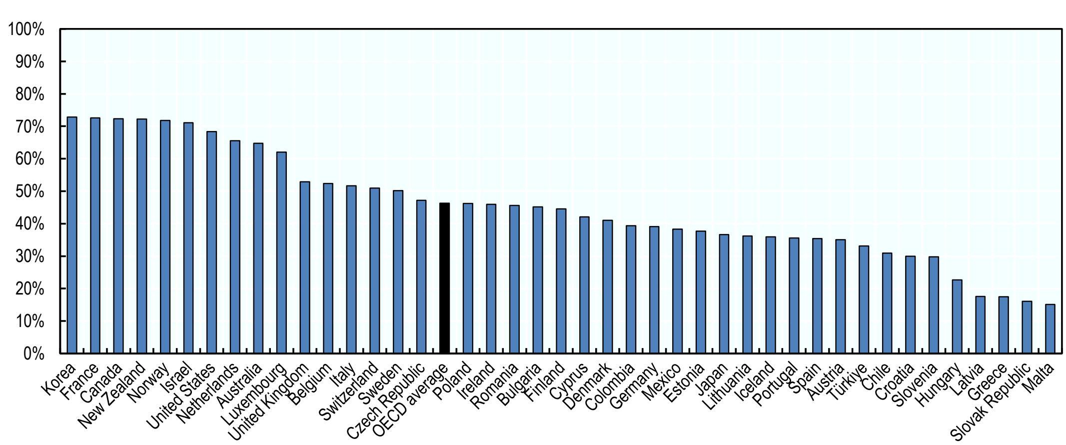
- The *Enlaces* programme in **Chile** aimed to develop teachers' digital skills and promote teachers' attitudes conducive to the use of digital technologies in classrooms. In 2018, the programme gave way to a new Innovation Center at the Ministry of Education, which broadened its mission to explore new teaching methodologies, practices and school processes. Its current flagship programmes include an ecosystem that continuously learns from promising innovations developed by teachers and schools throughout the country and advancing personalised learning opportunities in K12 education made possible by the use of technology (OECD, 2019[14]).

- As part of a national digital programme, Adapting the Education System for the 21st Century, **Israel** developed the Educational Cloud, a nationally run website offering extensive digital content for both educators and students. The Educational Cloud allows teachers to create and upload digital content and collaborate with other teachers on teaching in their classrooms. Furthermore, the guidelines for establishing an ICT Competent School provide schools with concrete directions on how to use the resource material effectively and collaboratively. The topics covered in these guidelines include infographics as a tool for information structuring, technologies for cultivating higher-order thinking skills and guidance on how to cultivate 21st century skills (OECD, 2019[14]).
- During the COVID-19 pandemic, **England** set up the EdTech Demonstrator Network, comprised of selected primary and secondary schools that had demonstrated their ability to effectively use digital technologies for teaching and learning and their capacity to help other schools and colleges with digital education (Department of Education, 2022[79]). Between 2020 and 2022 the network provided free peer-to-peer training and advice to over 2 500 state-funded schools and further education colleges on how they could make the best use of technology. The evaluation of the second programme phase highlighted positive effects of the programme on a range of outcomes including resource management and teacher workload (ImpactEd Ltd, 2022[80]).

Issuing guidance at the central or school level can be another strategy to spread best practices and promote the safe and effective use of digital education technologies in the classroom. In 2018, before the pandemic, 62% of 15-year-old students on average across OECD countries attended schools that had written school statements about the use of digital devices. However, only 46% of students attended a school with a written statement specifically about the use of digital devices for pedagogical purposes, although this share might have increased since the pandemic (see Figure 3.4). To support the use of digital education technologies outside of school, many governments have distributed electronic devices for students to use at home, particularly during the COVID-19 pandemic (OECD, 2021[81]). Policies and regulations that govern the use of digital technologies during off-site learning activities have therefore become more salient, as have regulations on data privacy and the collection of student data for learning analytics and other (commercial) purposes in general.

Figure 3.4. School guidelines on the use of digital devices for learning (2018)

Percentage of 15-year-old students in schools whose principal reported that their school has a written statement about the use of digital devices for pedagogical purposes



Note: Countries and economies are ranked in descending order of the proportion of schools reporting to have guidelines.
Source: OECD (2020[17]), *PISA 2018 Results (Volume V): Effective Policies, Successful Schools*, https://doi.org/10.1787/ca768d40-en, Table V.B1.5.18

The link between schools' practices regarding the use of digital technologies and students' outcomes remains to be further explored. Results of PISA 2018 established no association across OECD countries between schools' practices for effectively using digital devices and students' reading scores, after accounting for students' and schools' socio-economic profile (OECD, 2020[17]). Public authorities should also be attuned to potential inequities arising from differences in schools' capacity to promote the use of digital education technologies. For example, principals' reports in PISA 2018 suggest that socio-economically advantaged schools were more likely to offer guidelines for teachers and take actions to enhance teaching and learning using digital devices (OECD, 2020[82]; OECD, 2020[17]). These differences in capacity should be addressed to avoid the risks of exacerbating existing digital divides.

Adapt curricula and assessment frameworks

…to leverage the potential of digital education technologies

Curricula at different levels of education can be adapted to leverage the potential of digitalisation and support the use of digital education technologies for teaching. One of the trends observed in OECD countries over recent decades has been the digitalisation of curricula, which may involve the inclusion of digital curriculum resources, dynamic features and enhanced accessibility on electronic devices and interfaces for teachers and students (Pepin et al., 2017[83]). Hosting curricula on digital platforms can make it easier for students and teachers to access content in a non-linear way and to navigate curriculum contents on similar themes (e.g. sustainable development) across subjects. This can spur collaboration between teachers of different disciplines and help school leaders to develop specific competencies systematically by joining efforts across different subjects and levels. Interactive digital curricula can also allow users (e.g. teachers, local authorities) to design lessons, pedagogical activities and tailored curricula within online platforms.

Efforts to digitalise curricula have ranged from making curricula documents available in digital formats (this was the case in many OECD countries, incl. New Zealand, the Netherlands, Mexico and Lithuania) to the use of fully interactive digital curricula (e.g. in Australia, Estonia and Norway) that enable teachers to adapt learning contents to the specific characteristics and needs of their schools and students (OECD, 2020[57]):

- **New Zealand** has invested in systematically digitalising its curriculum documents, making them available as PDF, HTML and Word documents. The New Zealand Curriculum Online provides an array of resources to support teachers and schools as they design and review their school curricula (OECD, 2020[57]; Ministry of Education, 2016[84]).
- **Estonia** is funding and encouraging the use of digital textbooks, which teachers and students can access through an interactive learning platform called *Opiq.ee*. The e-textbooks mirror the contents of traditional textbooks but provide references across textbooks and links to additional materials, such as visual simulations of experiments. The platform also allows teachers to customise curriculum contents and, through an e-diary function, manage individual students' assignments and progress (OECD, 2020[57]).
- **Norway**'s renewed curriculum was adopted in 2020, following an open consultation process. The curriculum is online and fully interactive, allowing teachers to filter contents and find the resources and guidelines they need to implement the curriculum in a way that is adapted to their context (OECD, 2020[85]).

Some countries have also adapted their curricula to make explicit reference to the use of digital education technologies in order to facilitate their integration into the teaching process (OECD, 2019[8]). For instance, as of 2022, **Greece** has been gradually implementing revised national school curricula, which aim to promote the effective use of digital technologies for teaching and learning in line with the European Commission's Digital Education Action Plan 2021-2027. In addition to placing a greater emphasis on digital skills, the revised curricula are accompanied by digital materials to support teaching in all cognitive areas.

The revision of curricula took place during a time of significant investments in digital equipment through the European Recovery Fund. This included 36 000 interactive smartboards for all Greek schools from Grade five (EUR 30 million) and 177 000 robotics kits (EUR 150 million) (Eurydice, 2022[86]; Eurydice, 2023[87]).

Digital technologies also provide a range of opportunities for modernising assessment systems. Computer-based assessments allow educators to integrate new question types, for instance, drawing on video material or simulations. Some question formats also allow automatic grading if conducted in a computer-based format and thus provide the opportunity for efficiency gains (National Foundation for Educational Research, n.d.[88]). Some countries – particularly in Northern Europe - have started to reap these benefits by utilising digital devices for their high-stakes assessments:

- Between 2016 and 2019, **Finland** has gradually rolled out a computer-based format for the matriculation exams – the only high-stakes exams in K12 education in Finland. During the exam, students are prompted to use software installed on their computer, for instance to complete data tasks in Excel or statistical software. The open-source examination system is delivered by the Matriculation Examination Board and is compatible with a variety of device types (Ylioppilastutkintolautakunta studentexamensnämnden, 2021[89]).
- In **Sweden**, the government announced in 2017 that all national tests would be digitalised by 2022 (Löfven and Ekström, 2017[90]). The Swedish Association of Local Authorities, together with the National Agency for Education and the Swedish Edtech industry provide guidelines on how schools can fulfil these new requirements, including a list of suitable test providers. However, the ultimate responsibility for choosing adequate technologies and carrying out digital assessments remains with schools (RISE Research Institutes of Sweden, 2019[91]).

…to promote digital skills

Other curriculum reforms in OECD countries have focused more explicitly on the promotion of students' digital skills. Traditionally, many countries have taught digital skills primarily in dedicated digital or computational science classes (see the example of France below). Other countries have moved away from stand-alone digital skills classes and adopted a cross-curricular approach to digital skills, such as the digital competency framework developed by the **Australian** Curriculum, Assessment and Reporting Authority (ACARA) that takes a comprehensive approach to digital skills and encourages fostering them in other learning areas (OECD, 2019, p. 188[92]). Several recent examples of these different approaches are provided below:

- In **Israel**, the 2007 national programme, Adapting the Education System for the 21st Century, included a curriculum reform that strengthened the link between competency-based learning goals, innovative pedagogies and the use of digital technologies in classrooms. The programme promoted the implementation of the SAMR (Substitution, Augmentation, Modification and Redefinition) Model aimed at fostering meaningful uses of technology in teaching. As part of these efforts, teachers were provided with resources including a classroom-mapping sheet that allowed them to plan their use of digital technologies in the classroom. The programme also involved training of 28 to 56 hours and the opportunity to earn credits through successful completion that lead to wage improvements (OECD, 2019[14]).
- In 2019, **France** introduced mandatory courses on computational sciences and technology in secondary schools with the objective of teaching digital skills as a science but also of discussing the role of digital technologies in society (Ministère de l'Éducation nationale, 2019[93]). The government also encouraged the creation of extracurricular coding workshops and will progressively introduce a certification of digital skills for students in their last secondary school year (OECD, 2019[92]).

- Between 2012 and 2016, **Estonia** implemented the ProgeTiger programme, aimed at preschool, primary and vocational education students (Education Estonia, 2021[94]). The programme's aim was to enhance the digital competence of students by integrating technology education in the curriculum, by training teachers and by financing digital infrastructure acquisition by schools (Redecker et al., 2017[95]). The programme required teachers to integrate technology in different subjects, allowing them to choose the type of technology they would use. Teachers had access to face-to-face and online training and benefitted from the support of local networks related to the programme (OECD, 2019[92])

Key messages

Currently, the potential of digital technologies is far from exploited in education systems across OECD and EU countries: Uses of digital technologies for teaching and learning remain relatively infrequent and limited to basic technologies, although there has likely been significant progress throughout the pandemic.

Among other factors, this chapter highlights that inadequacy of digital technologies for education settings and a lack of confidence in their effectiveness are likely reasons for their limited take-up. It also presents a range of promising examples of policies which can ensure that education technologies fit educators' and students' needs. This might include central support for the selection of adequate digital technologies and opportunities for close exchange between players in the education sector and EdTech developers.

Further, changes in curricula and assessment frameworks are required to formally anchor the use of digital technologies and the acquisition of digital skills in education systems. Whilst digital curricula reforms are slowly spreading across countries, these reforms are largely limited to the teaching of digital skills and include few provisions to facilitate the use of digital tools for teaching and learning more generally. In addition to adapting curricula, providing guidance on the use of digital technologies, and opportunities for peer-learning and resource sharing among educators might facilitate pedagogical innovation.

References

Alelo (2023), *Alelo*, https://www.alelo.com/about-us/ (accessed on 5 April 2023). [13]

Arroyo, I. et al. (2014), "A multimedia adaptive tutoring system for mathematics that addresses cognition, metacognition and affect", *International Journal of Artificial Intelligence in Education*, Vol. 24/4, pp. 387-426, https://doi.org/10.1007/s40593-014-0023-y. [12]

Bates, T. et al. (2020), *Can artificial intelligence transform higher education?*, International Journal of Educational Technology in Higher Education 17, 42. [53]

Bernacki, M., L. Vosicka and J. Utz (2020), "Can a brief, digital skill training intervention help undergraduates "learn to learn" and improve their STEM achievement?", *Journal of Educational Psychology*, Vol. 112/4, pp. 765-781, https://doi.org/10.1037/EDU0000405. [54]

Bond, M. et al. (2020), "Mapping research in student engagement and educational technology in higher education: A systematic evidence map", *International Journal of Educational Technology in Higher Education*, Vol. 17/2, pp. 1-30, https://doi.org/10.1186/S41239-019-0176-8. [43]

Bond, M. et al. (2018), "Digital Transformation in German higher education: student and teacher perceptions and usage of digital media", *International Journal of Educational Technology in Higher Education*, https://educationaltechnologyjournal.springeropen.com/track/pdf/10.1186/s41239-018-0130-1.pdf. [51]

British Educational Suppliers Association (nd), *About LendEd*, https://www.lended.org.uk/about/. [64]

Brown, M., N. Millichap and J. Dehoney (2015), "What's Next for the LMS?", *EDUCAUSE Review*, Vol. 50/4, https://er.educause.edu/articles/2015/6/whats-next-for-the-lms (accessed on 6 May 2022). [27]

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. [29]

Cabero-Almenara, J. et al. (2021), "Digital competence of higher education professor according to DigCompEdu. Statistical research methods with ANOVA between fields of knowledge in different age ranges", *Education and Information Technologies*, Vol. 26, pp. 4691-4708, https://doi.org/10.1007/s10639-021-10476-5. [48]

Chernikova, O. et al. (2020), "Simulation-based learning in higher education: a meta-analysis", *Review of Educational Research*, Vol. 90/4, pp. 499–541, https://doi.org/10.3102/00. [41]

Conrads, J. et al. (eds.) (2017), *Digital Education Policies in Europe and Beyond: Key Design Principles for More Effective Policies*, Publications Office of the European Union, Luxembourg, https://doi.org/10.2760/462941. [95]

Cukurova, M., R. Luckin and A. Clark-Wilson (2018), "Creating the golden triangle of evidence-informed education technology with EDUCATE", *British Journal of Educational Technology*, Vol. 50/2, pp. 490-504, https://doi.org/10.1111/bjet.12727. [69]

Damşa, C. et al. (2015), *Quality in Norwegian higher education: a review of the research on aspects affecting student learning*, Report 2015-24, NIFU Oslo. [35]

Department of Education (2022), *EdTech demonstrator schools and colleges: about the programme*, https://www.gov.uk/government/publications/edtech-demonstrator-schools-and-colleges-successful-applicants/about-the-programme (accessed on 3 April 2023). [79]

Education Estonia (2021), *ProgeTiger: Estonian way to create interest in technology*, https://www.educationestonia.org/progetiger/ (accessed on 25 July 2022). [94]

European Commission (2020), *Commission Staff Working Document Accompanying the Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions "Digital Education Action Plan (2021-2027)"*, European Commission, Brussels, https://eur-lex.europa.eu/legal-content/LT/TXT/?uri=CELEX:52020SC0209 (accessed on 7 April 2022). [67]

European Commission (2013), *Survey of Schools: ICT in Education - Benchmarking Access, Use and Attitudes to Technology in Europe's Schools*, Directorate-General for the Information Society and Media (European Commission), Brussels, https://doi.org/10.2759/94499. [50]

Eurydice (2023), *Greece: National reforms in school education*, https://eurydice.eacea.ec.europa.eu/national-education-systems/greece/national-reforms-school-education (accessed on 7 April 2023). [87]

Eurydice (2022), *Greece: National Curriculum revision*, https://eurydice.eacea.ec.europa.eu/news/greece-national-curriculum-revision (accessed on 7 April 2023). [86]

Falck, O., C. Mang and L. Woessmann (2018), "Virtually no effect? Different uses of classroom computers and their effect on student achievement", *Oxford Bulletin of Economics and Statistics*, Vol. 80/1, pp. 1-38, https://doi.org/10.1111/OBES.12192. [34]

Federal Ministry of Education, S. (2020), *8-Point Plan for Digital Learning*, https://www.bmbwf.gv.at/en/Topics/school/krp/8_p_p.html (accessed on 11 July 2022). [76]

Fominykh, M. et al. (2019), *Digital Competences in Language Education Teachers' Perspectives, Employers' Expectations, and Policy Reflections*, DC4LT Consortium, https://www.dc4lt.eu/ (accessed on 21 June 2022). [33]

Fraillon, J., W. Schulz and J. Ainley (2013), *International Computer and Information Literacy Study (ICILS): Assessment Framework*, International Association for the Evaluation of Educational Achievement (IEA), Amsterdam, https://www.acer.org/files/ICILS_2013_Framework.pdf (accessed on 8 April 2022). [7]

Frauenberger, C., J. Good and W. Keay-Bright (2011), "Designing technology for children with special needs: Bridging perspectives through participatory design", *CoDesign*, Vol. 7/1, pp. 1-28, https://doi.org/10.1080/15710882.2011.587013. [71]

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). [4]

Gil-Flores, J., J. Rodríguez-Santero and J. Torres-Gordillo (2017), "Factors that explain the use of ICT in secondary-education classrooms: The role of teacher characteristics and school infrastructure", *Computers in Human Behavior*, Vol. 68, pp. 441-449, https://doi.org/10.1016/j.chb.2016.11.057. [47]

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. [68]

Guiney, P. (2016), *E-learning Provision, Participation and Performance*, New Zealand Ministry of Education, https://www.educationcounts.govt.nz/publications/tertiary_education/e-learning/e-learning-provision,-participation-and-performance. [25]

Hill, J. (2022), "Policy responses to false and misleading digital content : A snapshot of children's media literacy | OECD Education Working Papers | OECD iLibrary", OECD, Paris, https://www.oecd-ilibrary.org/education/policy-responses-to-false-and-misleading-digital-content_1104143e-en (accessed on 1 June 2023). [58]

Hippe, R., A. Pokropek and P. Costa (2021), "Cross-country validation of the SELFIE tool for digital capacity building of vocational education and training schools (in preparation)". [20]

ImpactEd Ltd (2022), "EdTech Demonstrator Programme (Phase 2-2021 to 2022) Evaluation", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1115740/EdTech_Demonstrator_Impact_Evaluation_Report_November_2022.pdf (accessed on 3 April 2023). [80]

INTEF (2019), *Samsung Smart School*, https://intef.es/tecnologia-educativa/samsung-smart-school/ (accessed on 6 April 2023). [73]

Jaschik, S. and D. Lederman (2019), *Inside Higher Ed 2019 Survey of faculty attitudes on technology*, Inside Higher Education, https://www.insidehighered.com/news/survey/survey-faculty-attitudes-technology [24]

Jean, A. and C. Gilger (2022), *Partnership for innovation and artificial intelligence (P2IA)*, https://primabord.eduscol.education.fr/partenariat-d-innovation-et-intelligence-artificielle-p2ia (accessed on 3 April 2023). [70]

JISC (nd), *Libraries, learning resources and research*, https://www.jisc.ac.uk/libraries-and-research. [63]

Kirkwood, A. and L. Price (2014), *Technology-enhanced learning and teaching in higher education: what is 'enhanced' and how do we know? A critical literature review*, Learning, media and technology, 39(1), 6-36. [37]

Labster (2022), *Labster website*, https://www.labster.com/ (accessed on 21 July 2022). [23]

Ledger, S. (2019), *Simulation in higher education: choice, challenges and changing practice*, https://doi.org/10.2991/icei-19.2019.91. [42]

LendED (2022), *LendED - Your EdTech lending platform*, https://www.lended.org.uk/about/ (accessed on 4 May 2022). [65]

Lincoln Electric (2022), *Lincoln Electric Education Solutions*, https://www.lincolnelectric.com/en/Education (accessed on 21 July 2022). [21]

Löfven, S. and A. Ekström (2017), *Nationella prov – rättvisa, likvärdiga, digitala*, https://www.regeringen.se/contentassets/4d631707555d41318fc5d8e4eeb39ac2/nationella-prov--rattvisa-likvardiga-digitala-prop.-20171814.pdf (accessed on 2 May 2023). [90]

Machajewski, S. et al. (2018), “Patterns in faculty learning management system use”, *TechTrends*, Vol. 63/4, https://doi.org/10.1007/s11528-018-0327-0. [36]

Martin, F. et al. (2020), *Examining higher education faculty use of current digital technologies: importance, competence, and motivation*, http://www.isetl.org/ijtlhe/. [38]

Martin, L. (2020), *Foundations for Good Practice: The Student Experience of Online Learning in Australian Higher Education During the COVID-19 Pandemic*, Tertiary Education Quality and Standards Agency, Melbourne, https://www.teqsa.gov.au/sites/default/files/student-experience-of-online-learning-in-australian-he-during-covid-19.pdf?v=1606953179 (accessed on 11 July 2022). [3]

Matear, S. (2021), *Good Practice Assessment of Online Teaching in Universities in Aotearoa New Zealand during the COVID-19 Pandemic and Lessons for the Future*, Academic Quality Agency, Wellington, https://www.aqa.ac.nz/sites/all/files/GPA%20Report%20FINAL.pdf (accessed on 11 July 2022). [2]

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. [30]

Ministère de l’Éducation nationale (2019), *Le Numérique au Service de l’École de la Confiance*, https://www.education.gouv.fr/sites/default/files/imported_files/document/DP-LUDOVIA_987361.pdf (accessed on 25 July 2022). [93]

Ministry of Education (2016), *New Zealand Curriculum Online*, https://nzcurriculum.tki.org.nz/About-New-Zealand-Curriculum-Online (accessed on 11 April 2023). [84]

Molenaar, I. (2021), “Personalisation of learning: Towards hybrid human-AI learning technologies”, in *OECD Digital Education Outlook 2021: Pushing the Frontiers with Artificial Intelligence, Blockchain and Robots*, OECD Publishing, Paris, https://doi.org/10.1787/2cc25e37-en. [9]

National Forum (2021), *National Resource Hub (National Forum for the Enhancement of Teaching and Learning in Higher Education)*, https://hub.teachingandlearning.ie/ (accessed on 6 April 2023). [75]

National Foundation for Educational Research (n.d.), *What are the benefits of Computer-Based Assessment? - NFER*, https://www.nfer.ac.uk/for-schools/free-resources-advice/assessment-hub/ask-the-expert/what-are-the-benefits-of-computer-based-assessment/ (accessed on 28 April 2023). [88]

OECD (2022), *Mending the Education Divide: Getting Strong Teachers to the Schools That Need Them Most*, TALIS, OECD Publishing, Paris, https://doi.org/10.1787/92b75874-en. [45]

OECD (2022), *Value for Money in School Education: Smart Investments, Quality Outcomes, Equal Opportunities*, OECD Publishing, Paris, https://doi.org/10.1787/f6de8710-en. [31]

OECD (2021), *21st-Century Readers: Developing Literacy Skills in a Digital World*, PISA, OECD Publishing, Paris, https://doi.org/10.1787/a83d84cb-en. [32]

OECD (2021), *Education Policy Outlook 2021: Shaping Responsive and Resilient Education in a Changing World*, OECD Publishing, Paris, https://doi.org/10.1787/75e40a16-en. [77]

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. [46]

OECD (2021), *Supporting the Digital Transformation of Higher Education in Hungary*, Higher Education, OECD Publishing, Paris, https://doi.org/10.1787/d30ab43f-en. [1]

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. [19]

OECD (2021), *The State of Global Education: 18 Months into the Pandemic*, OECD Publishing, Paris, https://doi.org/10.1787/1a23bb23-en. [81]

OECD (2020), "Education Policy Outlook in Norway"*, OECD Education Policy Perspectives*, No. 20, OECD Publishing, Paris, https://doi.org/10.1787/8a042924-en. [85]

OECD (2020), *Global Teaching InSights: A Video Study of Teaching*, OECD Publishing, Paris, https://doi.org/10.1787/20d6f36b-en. [5]

OECD (2020), "Learning remotely when schools close: How well are students and schools prepared? Insights from PISA"*, OECD Policy Responses to Coronavirus (COVID-19)*, OECD Publishing, Paris, https://doi.org/10.1787/3bfda1f7-en. [82]

OECD (2020), *PISA 2018 Results (Volume V): Effective Policies, Successful Schools*, PISA, OECD Publishing, Paris, https://doi.org/10.1787/ca768d40-en. [17]

OECD (2020), *TALIS 2018 Results (Volume II): Teachers and School Leaders as Valued Professionals*, TALIS, OECD Publishing, Paris, https://doi.org/10.1787/19cf08df-en. [15]

OECD (2020), *What Students Learn Matters: Towards a 21st Century Curriculum*, OECD Publishing, Paris, https://doi.org/10.1787/d86d4d9a-en. [57]

OECD (2019), *Benchmarking Higher Education System Performance*, OECD Publishing, https://doi.org/10.1787/be5514d7-en. [49]

OECD (2019), *OECD Learning Compass 2030: A Series of Concept Notes*, http://www.oecd.org/education/2030-project/contact/OECD_Learning_Compass_2030_Concept_Note_Series.pdf (accessed on 13 December 2022). [56]

OECD (2019), *OECD Skills Outlook 2019: Thriving in a Digital World*, OECD Publishing, Paris, https://doi.org/10.1787/df80bc12-en. [92]

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

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. [14]

OECD (2018), *PISA 2018 Database*, https://www.oecd.org/pisa/data/2018database/. [18]

OECD (2013), *Synergies for Better Learning: An International Perspective on Evaluation and Assessment*, OECD Reviews of Evaluation and Assessment in Education, OECD Publishing, Paris, https://doi.org/10.1787/9789264190658-en. [59]

OECD (n.d.), *PILA*, https://pilaproject.org/ (accessed on 23 May 2023). [61]

Page, L. and H. Gehlbach (2017), "How an artificially intelligent virtual assistant helps students navigate the road to college:", *AERA Open*, Vol. 3/4, pp. 1-12, https://doi.org/10.1177/2332858417749220. [55]

Pane, J. et al. (2014), "Effectiveness of Cognitive Tutor Algebra I at scale", *Educational Evaluation and Policy Analysis*, Vol. 36/2, pp. 127-144, https://doi.org/10.3102/0162373713507480. [11]

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. [60]

Pepin, B. et al. (2017), "Digital curriculum resources in mathematics education: Foundations for change", *ZDM Mathematics Education*, Vol. 49/5, pp. 645-661, https://doi.org/10.1007/s11858-017-0879-z. [83]

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. [72]

Price, L. and A. Kirkwood (2011), *Enhancing Professional Learning and Teaching Through Technology: A Synthesis of Evidence-based Practice Among Teachers in Higher Education*, Higher Education Academy, York, https://www.lth.se/fileadmin/lth/genombrottet/DTR/PLATP_Main_Report_2011.pdf (accessed on 11 July 2022). [44]

Redecker, C. (2017), *European Framework for the Digital Competence of Educators: DigCompEdu*, European Commission, Joint Research Centre, https://doi.org/10.2760/159770. [62]

RISE Research Institutes of Sweden (2019), *Some experiences from the first digital national writing test in year 9* | *RISE*, https://www.ri.se/en/some-experiences-from-the-first-digital-national-writing-test-in-year-9 (accessed on 2 May 2023). [91]

Seel, N. (ed.) (2012), *Learning management systems.*, Springer, https://doi.org/10.1007/978-1-4419-1428-6_187. [28]

Simula Games (2022), *Simula Games Truck and Logistics Simulator*, https://simulagames.com/ (accessed on 21 July 2022). [22]

Snappet (2023), *Snappet*, https://snappet.nl/ (accessed on 5 April 2023). [10]

SURF (nd), *About SURF*, https://www.surf.nl/over-surf (accessed on 5 May 2023). [66]

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). [16]

Thillay, A., A. Jean and Q. Vidal (2020), “France: Les banques de ressources numériques éducatives (BRNE) (Banks of educational digital resources)”*, Education continuity during the Coronavirus crisis*, OECD Publishing, Paris, https://oecdedutoday.com/wp-content/uploads/2020/09/France-Banks-of-educational-digital-resources.pdf (accessed on 24 April 2022). [74]

Tømte, C. et al. (2019), “Digitalisation in higher education: mapping institutional approaches for teaching and learning”, Vol. 25/1, https://doi.org/10.1080/13538322.2019.1603611. [26]

Tsai, Y. et al. (2020), “Learning analytics in European higher education—trends and barriers”, *Computers & Education*, Vol. 155, https://doi.org/10.1016/j.compedu.2020.103933. [39]

van der Vlies, R. (2020), “Digital strategies in education across OECD countries: Exploring education policies on digital technologies”*, OECD Education Working Papers*, No. 226, OECD Publishing, Paris, https://doi.org/10.1787/33dd4c26-en. [78]

Viberg, O. et al. (2018), “The current landscape of learning analytics in higher education”, *Computers in Human Behavior*, Vol. 89, pp. 98–110, https://doi.org/10.1016/j.chb.2018.07.027. [40]

Vijayakumar, B., S. Höhn and C. Schommer (2019), “Quizbot: Exploring formative feedback with conversational interfaces”, in Draaijer, S., D. Joosten-ten Brinke and E. Ras (eds.), *Technology Enhanced Assessment. TEA 2018. Communications in Computer and Information Science*, Springer, Cham, https://doi.org/10.1007/978-3-030-25264-9_8/COVER/. [52]

Whitmer, J. et al. (2016), *Patterns in Blackboard Learn tool use: Five course design archetypes*, Blackboard, https://www.blackboard.com/sites/default/files/resource/pdf/Bb_Patterns_LMS_Course_Design_r5_tcm136-42998.pdf (accessed on 5 May 2022). [6]

Ylioppilastutkintolautakunta studentexamensnämnden (2021), *Digital Matriculation Examination*, https://www.ylioppilastutkinto.fi/en/matriculation-examination/digital-matriculation-examination (accessed on 28 April 2023). [89]

Notes

[1] For the purpose of the analysis of TALIS data, VET teachers were defined as those who reported teaching practical and vocational skills in the survey year, regardless of their type of programme or school. This data was available for Sweden, Portugal, Denmark, Slovenia, Canada (Alberta) and Türkiye (OECD, 2021, p. 17[19]).

[2] The figure was up from 30% in the same survey conducted in 2013. That indicates a large increase over the six years but from a relatively low base.

[3] Guiney (2016[25]) measures the extent of the use of digitalisation weighted by the number of equivalent full-time students enrolled.

[4] EDUCATE project at University College London, https://www.ucl.ac.uk/ioe/departments-and-centres/centres/ucl-knowledge-lab/educate (accessed on 25 April 2022).

[5] Simon Initiative at Carnegie Mellon University, https://www.cmu.edu/simon/ (accessed on 25 April 2022).

4 Guidance and regulatory frameworks for digital education

This chapter reviews the current guidance and regulations in place across OECD countries with respect to digital education. It highlights the nascent nature of many aspects of regulatory frameworks from the viewpoint of protecting learners in digital environments and ensuring their equitable access to the benefits of digital education. The chapter also stresses the need to ensure that quality assurance policies and practices are adapted and, where necessary, updated to take specific considerations related to digital education into account. Regulatory frameworks should also be designed to ensure compliance with important legal and ethical requirements related to digitalisation, such as child protection, data protection and the impact of AI and algorithms.

Introduction

This chapter examines the elements of a fit-for-purpose guidance and regulatory framework that can promote effective digital education and adapt to evolving needs, while protecting and supporting learners. Digital transformation of education requires ongoing policy efforts to provide and update guidance, standards and regulations. Accounting for specific education governance arrangements and understanding the distribution of roles and responsibilities in the education systems for digital education is crucial for this purpose. A fit-for-purpose policy framework for digital education is also one that leverages the involvement of all digital education stakeholders and ensures they can meaningfully contribute to seizing the potential of digital technologies in education systems.

Increasing cyber security risks, concerns about data protection and potential algorithmic bias increase the need for closer attention to the design of new guidance for compliance with existing digital security and data protection frameworks, and for regulation in areas that currently remain largely uncovered. This chapter examines the provision of standards, guidelines and formal regulations (with an associated legal obligation) to enable an efficient and safe use of digital education technologies. Public bodies need to provide support and guidance to education institutions for many aspects of digital education. These include compliance with legal and regulatory frameworks, making investment decisions, maximising technology interoperability and ensuring privacy protection and equitable practice.

Quality standards and guidelines for digital education can support institutions in making effective use of digital technologies that translate into better student outcomes. This requires developing a coherent quality assurance approach for digital education, clarifying focus areas to be covered as well as the intended use of the evaluation results (for accountability, identifying and promoting good practices and improving provision where it does not meet the required standards). There is also a need to ensure synergies and articulations between processes and tools to ensure coherence and consistency. International co-operation and co-ordination on setting standards for digital education technologies can support quality assurance efforts.

Education systems face a range of challenges in providing adequate governance and regulatory frameworks for digital education. This chapter aims to address these challenges by taking stock of the relevant evidence and presenting some promising policy examples from OECD and EU countries. Some of the key questions on this issue that policy makers need to consider include:

- How can education systems build a regulatory framework, design guidance and institutional capabilities that enable the protection of learners and ensure the quality of digital education?
- How can the regulatory framework for digital education be designed to adequately steer the use of emerging or fast-evolving technologies?
- How can education systems address the governance implications of increasingly digitalised schools and growing reliance on hybrid learning?
- How can education systems best engage different stakeholders to help achieve the potential of digital technologies in education?

Recent developments and current challenges

Learner protection measures and equitable practices in digital learning environments remain insufficient

Learners can face a wide variety of risks in a digital learning environment

Whilst digital technologies bring a wealth of opportunities to enhance learning experiences, they also entail a set of risks for learners and teachers. Responses from 34 countries to a 2017 OECD Policy Questionnaire on the protection of children online revealed a wide variety of online risks faced by children and considered to be relevant by policy makers (e.g. bullying, online privacy, hateful content, harmful overuse of connected devices and online services) (OECD, 2020[1]). Beyond potentially affecting children's development and well-being, these risks might also have tangible effects on their rights (e.g. right to privacy, right to no discrimination).

Students are also likely to face these risks when using digital technologies for learning. As the use of digital technologies in learning processes has expanded significantly throughout the pandemic, the risks entailed by digital technologies increasingly permeate education systems. For instance, the COVID-19 pandemic has substantially increased the amount of data shared in education settings, translating into heightened privacy risks for students (OECD, 2021[2]).

Education software or digital education platforms that reach students through schools may be subject to tight data protection or privacy regulations that may help mitigate against risks, especially if their developers follow principles of safety by design (UNICEF, 2022[3]). At the same time, such built in protections may not always be sufficient. Students may, for instance, still be vulnerable to cyberbullying through e-learning platforms or be exposed to a variety of risks (e.g. harmful content) when looking for information online for schoolwork. The collection, use and reuse of children's data from such platforms may also be problematic for children's privacy (OECD, 2022[4]). In addition, children may also be exposed if they disclose personal information unintentionally during learning processes, share or upload inappropriate content, or infringe on copyrights or other rights through plagiarism (UNICEF, 2022[3]).

This wide variety of risks that children potentially face in a digital learning environment increases the need for a co-ordinated and comprehensive legal and policy response. Almost all countries responding to the OECD Policy Questionnaire on the protection of children online in 2017 had introduced some form of legislative or policy response to address the risks faced by children in a digital learning environment (OECD, 2020[1]; Burns and Gottschalk, 2019[5]). At the time of the survey, however, most countries displayed fragmented approaches to children's protection in digital environments. Since then, the introduction of the General Data Protection Regulation (GDPR) in EU countries has translated into a heightened recognition of the special attention and protection children need with respect to their personal data, as well as increased efforts to raise public awareness regarding the processing of children's personal data (OECD, 2020[1]).

Enforcement likely varies across education institutions falling under European data protection regulations

The demand to show compliance in information security has been growing in the education sector, in line with the implementation of stricter regulation of the digital sphere, including the GDPR in Europe (EUR-Lex, 2016[6]). The GDPR considerably raised the level of accountability for European education institutions on the data they possess and collect, including data handled by third parties. To ensure GDPR compliance, education institutions need to:

- ensure all staff are informed about GDPR and understand how data is collected and stored and the implications of a breach (e.g. through training), including the need to report any instance to the Information Commissioner's Office (ICO);
- have systems in place to gather parental consent for data processing and verify individuals' ages;
- centralise information on software used for teaching and data collection as well as ensuring that all software comply with the GDPR;
- employ or assign a Data Protection Officer with a comprehensive knowledge of new data protection law to liaise with the ICO.

While the mandatory nature of GDPR standards promotes progress on data protection in education institutions, enforcement of the GDPR has likely varied across EU countries due to differences in the human, financial and technical resources devoted to enforcement (Ruohonen and Hjerppe, 2022[7]). In the higher education sector, survey data for 2020 indicated that 25 out of 43 NRENs in the Géant network stated having a privacy notice (including adherence to the GDPR) and 11 stated otherwise, indicating that by 2020 progress on GDPR compliance was not yet complete (Géant, 2020[8]).

While estimates on enforcement fines remain inaccurate since not all fines are made public, evidence suggests that data protection agencies had fined more than 20 education institutions (schools and universities) by 2022 across the EU. Fines were granted for a range of GDPR violations (mostly due to insufficient legal basis for data processing and insufficient technical and organisational measures to ensure information security) (CMS, n.d.[9]). The legal framework and consequences of non-compliance increase the pressure on education institutions to invest in data protection measures.

Applications of Artificial Intelligence in education require further research and regulatory efforts to protect learners and their rights

Applications of AI in education can raise concerns for learners' rights, such as their right not to suffer from discrimination, as well as for principles such as the transparency and explainability of AI systems, which are anchored in documents such as the UNCRC or national data protection laws (Holmes et al., 2022[10]). These concerns are particularly acute in situations where AI-based tools are used for high-stake decisions in education settings and without human oversight. Evidence on AI-powered education technologies, including early warning systems or classroom analytics, shows challenges related to algorithm accuracy (OECD, 2021[11]). In addition, many concerns remain about the potential bias of algorithms which can penalise specific population groups. Research highlights the manifestation of algorithmic bias in education with respect to a number of demographic categories (gender, ethnicity and nationality) (Baker and Hawn, 2021[12]). Furthermore, since research has tended to focus only on a selected number of demographic groups, it is likely that biases experienced by other demographic groups remain unidentified and undocumented, calling for further work to enhance the accuracy of algorithms.

High-stakes decisions in education systems made on the basis of potentially inaccurate or biased algorithms may lead to equity issues and unfairness in students' opportunities and outcomes. Even beyond algorithmic bias, the use of AI might have adverse effects on children's rights – including their rights to human dignity or autonomy – by diminishing the transparency and blurring the accountability of high-stakes decisions such as grading or grade-repetition (Holmes et al., 2022[10]). However, the risks and benefits of using advanced technologies must be assessed not only in absolute terms, but also relative to current arrangements. There is substantive evidence to suggest that teachers' implicit biases can impact high-stakes decisions in education systems (Bonefeld and Dickhäuser, 2018[13]). Whilst outsourcing such decisions to advanced technologies does not necessarily combat these biases, AI systems that are built with an equity lens can have the potential to detect and help teachers correct for existing biases (Perry and Turner-Lee, 2019[14]).

Regulatory efforts are thus needed to ensure that AI applications and their use in education settings are compliant with students' rights and a driving force against bias and discrimination in education systems. However, most OECD countries currently lack regulations for algorithms (OECD, 2021[11]), although a number of countries are considering regulations to enhance the transparency and accuracy of automated decision-making systems (Casovan and Shankar, 2022[15]). While the provisions on algorithm use in the GDPR are subject to conflicting legal interpretations and thus provide only limited guidance (OECD, 2021[11]), more recent efforts seek to design legislation targeting AI use in high-risk fields.

Education systems face increasing pressure to improve digital security and design digital risk-management approaches

Cyber security is the practice of protecting systems, networks and software programmes from digital attacks. The importance of cyber security has risen in recent years, given the reported significant and rising incidence of cyber-attacks, including phishing, ransomware and distributed denial of service attacks, as well as growing geopolitical tensions with risks of associated cyber-attacks. Education institutions are not immune to such cyber-attacks. Cyber security risks have rapidly expanded in education systems, in part due to a growing reliance on mobile devices, an expansion of remote or hybrid learning, and an increase in third-party education partners, which create more login points and a proliferation of vulnerable login credentials. Learners are also using education institution accounts to log in to a wider range of services: administrative portals, remote video and learning tools, and student web applications. This expansion of risk points drives an increase in data breaches and a surge in threats targeting vulnerable digital systems.

The security portfolio of education institutions to help mitigate attacks and vulnerability has grown in tandem with the rise in security risks. In larger education institutions it includes not only requirements for up-to-date operating systems and software and anti-virus software, but also more sophisticated tools such as Multi Factor Authentication, Virtual Private Networks (VPNs), end-user device management and remote data deletion.

In higher education, most NRENs in Europe have some kind of security audit of their organisation (Géant, 2020[8]). NRENs increasingly play a role in cyber security through network monitoring, specialist support when an institution comes under attack, and providing vital notifications of emerging threats and associated recommended actions. In some education systems cyber security services are provided by private firms that provide managed security services. These firms act to mobilise attention to cyber security risks – and offer commercial solutions to the risks they identify.

Progress in the implementation of interoperability frameworks has been slow in education systems

Interoperability is the ability of two or more systems (or components) to exchange information and use it in a seamless way, regardless of who the provider of the system is. Interoperability matters for access, quality, efficiency and security: it lowers the costs of technological transition, makes systems more adaptable by lowering the risk of provider lock-in, and allows for better monitoring of data and systems.

Education data and systems operate within general interoperability frameworks, including the European Interoperability Framework (European Commission, 2022[16]) and national frameworks where they exist, which are in some cases made specific to the education sector (e.g. the *Référentiel général d'interopérabilité* in **France** (République Française, 2020[17]) with more general technical guidelines including interoperability aspects currently under development). Institutions may complement these broader frameworks with one of the multiple public and proprietary interoperability standards and frameworks for education. However, progress in the implementation of interoperability frameworks has been slower in education, particularly compared to other sectors such as healthcare. Interoperability among learning environments remains insufficiently developed, triggering challenges with respect to the sustainability and affordability of digital education technologies (OECD, 2021[11]).

Quality assurance frameworks are not yet fully adapted to digital education

Evaluation and assessment tools are not always tailored to digital education

In school education systems, quality assurance policies and practices have become increasingly varied, including school self-evaluations, external school evaluations, national examinations, teachers and school leader appraisal, etc. The progressive increase in school autonomy has been associated with rising responsibilities for schools in the area of quality assurance (e.g. through a focus on school self-evaluations).

At the school level, internal and external evaluation mechanisms can play a role in enhancing the use of digital technologies for learning, teaching and management, although more needs to be done in adapting such mechanisms for digital education. Prior to the pandemic in 2018/19, 10 EU countries had included aspects related to digital education in their external school evaluation frameworks, with varying evaluation methods and data sources (e.g. surveys, classroom observation) (European Commission/EACEA/Eurydice, 2019[18]).

In **Estonia**, broader surveys on well-being at school include questions targeted to students, parents and teachers on the use of digital devices for learning, guidance received by students from teachers in this area, etc. In addition, students' digital competence was assessed as part of quality assurance procedures in lower and upper secondary education (European Commission/EACEA/Eurydice, 2019[18]). Schools were equally in charge of self-reporting on their digital infrastructure for education. In contrast, in other countries, such as **Romania** and **Latvia**, external school evaluation frameworks only focused on the availability of digital infrastructure for education, which likely limited their ability to assess the outcomes of learning with digital technologies. In a few other countries, the use of digital technologies for management purposes was also examined as part of external school evaluations.

More attention is needed regarding the design and scope of evaluation frameworks and tools, in order to adapt them to collect useful information about digitalisation. Relevant topics to be covered may include the quality of digital infrastructure, and teachers' and school leaders' preparedness to work with digital technologies. More consideration could also be given to the ways of using the results of such evaluations (e.g. for identifying and promoting good practices).

More recent developments of digital education strategies, as well as pandemic-related measures for digital education, suggest that countries are increasingly putting an emphasis on quality assurance tools for digital education. The rise in the provision of online school education has also triggered increased demand for regulation of online learning provision in some countries. For instance, in the **United Kingdom**, the Department for Education is developing an Online Education Accreditation Scheme targeted at providers of full-time online education for children who cannot attend school in person (GOV.UK, 2021[19]). The new accreditation aims at increasing standards of full-time online education, while also informing parents' choices. The scheme relies on establishing non-statutory standards for online education provision and inspection of providers against these standards by the Office for Standards in Education, Children's Services and Skills (a non-ministerial department in charge of inspecting education providers for all ages and skills).

Beyond quality assurance for online learning, the pandemic has also triggered an increase in policy efforts aimed at expanding the provision of digital education resources more generally but also at better assessing and certifying their quality. Systematic and comprehensive cross-country evidence on how countries have adapted and developed their quality assurance strategies for digital school education remains, however, relatively limited.

Some transnational quality assurance organisations have developed specific guidance for the quality assurance of e-learning in higher education

In European higher education, the European Network for Quality Assurance Agencies in the European Higher Education Area (ENQA) seeks to encourage quality assurance agencies and HEIs to use the *European Standards and Guidelines for Quality Assurance in the European Higher Education Area (ESG)* (E4 Group, 2015[20]). The ESG provide a set of standards and guidelines[1] for internal and external quality assurance related to "learning and teaching in higher education, including the learning environment and relevant links to research and innovation". The ESG (2015[20]) state that the standards and guidelines apply to "all higher education offered in the EHEA regardless of the mode of study or place of delivery" (E4 Group, 2015[20]), an approach seconded by other international quality assurance networks. For instance, in its *Guidelines of Good Practice*, the International Network of Quality Assurance Agencies in Higher Education (INQAAHE) states that their "standards or criteria take into consideration the specific aspects related to different modes of provision, such as transnational education, distance or online programmes or other non-traditional approaches." (INQAAHE, 2018, p. 7[21]).

While INQAAHE and ENQA do not believe it is necessary to revise the overarching approach to quality standards, they have suggested that quality assurance agencies and HEIs include specific e-learning considerations in their existing quality frameworks, adapt existing evaluation methods and strengthen their internal expertise for the evaluation and revision of digital study programmes. To support the development of specific quality standards for digital higher education, an ENQA Working Group has developed "Considerations for the quality assurance of e-learning provision" (Huertas et al., 2018[22]). The report includes a list of "elements to consider" and "indicators", but they are not legally binding for quality assurance agencies and institutions and have been developed independently from the ESG. In addition, INQAAHE's 2022 release of international standards and guidelines for quality assurance includes a specific module on online and blended modalities (INQAAHE, 2022[23]).

Few national quality assurance agencies have developed standards and processes for the quality assurance of digital higher education

Many national higher education quality assurance agencies in Europe have not yet developed quality standards and processes to degree programmes in fully online or hybrid formats. They have found it challenging to develop a shared understanding of what quality in digital higher education means (Tait, 2022[24]; Gaebel et al., 2021[25]) and to adapt standards and processes developed for traditional face-to-face provision to digital provision. Many quality assurance agencies lack institutional capacity or expertise to expand the scope of their activities to encompass digital provision. This is particularly relevant in smaller EU jurisdictions and for quality assurance agencies that carry heavy administrative responsibilities arising from their role as accreditors of individual study programmes.

Programme accreditation processes can also support or inhibit the expansion of digital study programmes offered by higher education institutions. For example, in **Hungary** there were only 45 accredited fully online distance learning (DL) programmes on offer in 2021, which represents a small share of the total of 11 246 accredited higher education study programmes in the country (FELVI, 2021[26]). One reason for this is that higher education institutions must meet a number of detailed "special provisions for distance education programmes" (Netjogtar, 2022[27]) in addition to a core set of requirements applicable to all programmes regardless of their delivery mode. Similarly, in **Croatia**, online programmes must meet a strict set of specific criteria in order to be accredited by the quality assurance agency (OECD, 2023[28])

To encourage institutions to offer more high-quality DL programmes, **Romania** recently revised its *ex-ante* programme accreditation procedures, providing institutions with the opportunity to be granted "provisional operation authorisation" for DL programmes if they have the required financial and online learning resources in place to offer at least one full study cycle. Within two years of launching the DL programme, institutions need to apply for full programme accreditation (ARACIS, 2020[29]).

Many European HEIs already have internal quality standards in place for digital education

The primary responsibility for quality assurance lies with HEIs themselves. A major survey of 368 institutions from 48 European countries administered in 2020 by the European University Association (Gaebel et al., 2021[25]) found that 51% of HEIs had already integrated digitally enhanced teaching and learning considerations in their internal quality assurance procedures, and measures were under development in another 41% of responding institutions. This represents a significant increase compared to 2014, when the figures were 29% and 35% respectively. This shift is driven by the priority attached to digitalisation: three-quarters of survey respondents had concrete plans to boost digital capacity beyond the pandemic, and 95% saw digitalisation as a strategic priority over the next five years.

Promising approaches for creating an effective guidance and regulatory framework

Establish a regulatory framework to guide digital education, and ensure it is adaptable to evolving needs

Provide guidance and resources to support compliance with existing digital security and data protection frameworks

Education institutions across OECD countries face increasing challenges in ensuring the security of their activities online and complying with regulations aimed at supporting the privacy of their learners' data. While the regulatory framework might be present, compliance with its requirements often requires additional resources. In this context, some countries provide guidance for education institutions, teachers and learners, as well as practical and content related resources to help them adapt in a fast-changing technological and regulatory environment:

- In **France,** the Ministry of Education and the national data protection authority signed an agreement in 2015 to provide training and resources for raising awareness and preparing teachers and school leaders on GDPR processes (OECD, 2020[1]). In addition, the national data protection authority developed a reference framework for the training of students specifically devoted to data protection (Eduscol, 2022[30]). The framework is intended to be used as part of school courses as well as in the training courses of education staff, regardless of the subject taught, with the aim of building a common base of concrete skills in the field of personal data protection. Initiated by the French national data protection authority, the reference framework was also adopted at the international level by other data protection authorities in 2016 (International Working Group on Digital Education, 2016[31]). Beyond building capacity and providing guidance on data protection, the French Ministry has also provided practical resources to secure user data. For instance, the GAR (*Gestionnaire d'Accès aux ressources*) is an authentication system supported by the French Ministry of Education that allows students and teachers to access education material through a single identifier, thus enhancing security and protecting users' personal data (Ministère de l'éducation nationale, n.d.[32]).
- The Department for Education in the **United Kingdom** prepared a data protection toolkit to support schools with data protection activities and compliance with the Data Protection Act that implements the GDPR (Department for Education, 2019[33]). In addition, the National Cyber Security Centre provides practical resources targeted at school governing boards, senior leaders and school staff to support their understanding of cyber security, help them work safely on line, and effectively detect, manage and solve any incidents (NCSC, 2021[34]).
- The **United States** Department of Education has created a Privacy Technical Assistance Center (PTAC) which provides privacy toolkits and training materials for the benefit of education institutions at early childhood education and care, school and post-secondary levels, as well as for

the benefits of parents and students. It is designed to be a "one-stop" resource for queries related to privacy and data protection in education (US Department of Education, n.d.[35]).

Design a co-ordinated policy approach to support children's protection in digital learning environments

As described previously, students' uses of digital tools for education purposes are not contained to designated learning platforms. Rather, students draw on a range of online resources when searching for learning-related information. Many countries have thus taken a holistic approach to address risks stemming from children's engagement in digital environments (e.g. cyberbullying, data privacy-related risks, harmful content) including but not limited to digital education environments. Regulations have targeted the providers of digital technologies, services or content and – in the context of digital education – those involved in the use of such technologies for learning (e.g. education institutions, teachers). As part of the OECD Recommendation of the Council on Children in the Digital Environment, the OECD has put forward guidelines for digital services providers calling on them to adopt a "child safety by design" approach, ensure effective information provision transparency and accountability, establish safeguards and take precautions regarding children's privacy and data protection (OECD, 2021[36]).

Other efforts for international co-operation or co-ordination regarding standards-setting on children's data protection have also emerged. For instance, the International Conference of Data Protection and Privacy Commissioners' working group on digital education has passed resolutions on e-learning platforms and privacy in education (OECD, 2020[1]). At the national level, as of 2017, co-ordinated and targeted approaches for the protection of children in digital environments were not widespread yet, although a few OECD countries had accompanied more targeted legislation with the establishment of statutory oversight bodies for online privacy protection (OECD, 2020[1]).

Further co-operation at the national level should accompany international co-operation efforts on children's protection in digital learning environments. Education authorities should be engaged in regulatory efforts or discussions at the government level to ensure specific risks related to the use of digital technologies in education are taken into consideration in the design of legal or policy responses. Designing an appropriate legal and regulatory framework to guide a safe use of digital technologies in learning processes also requires co-operation among a variety of stakeholders for child protection. Such stakeholders may include education institutions, teacher and parent organisations, digital education technology developers and the research community, as well as government authorities and agencies with responsibilities for education, child protection, and social services. (UNICEF, 2022[3]).

Share services to achieve standardisation and cost-efficiency in data protection and cyber security solutions

Considering the growing significance and complexity of data standards, prior OECD recommendations advocate for appointing national expert panels to evaluate, compare, and enhance government and institutional digital and data policies, encompassing personal data protection, content sharing and usage, and data integrity within digital learning environments (OECD, 2021[37]).

Networks and associations can provide an effective vehicle to promote compliance with data protection frameworks in education institutions:

- In **Europe**, Géant provides training and support documents on data protection compliance to its member organisations. It also hosts a special interest group on information security management where Chief Information Security Officers exchange knowledge and experiences. A task force of security incident response teams also works to improve co-operation and co-ordination, to promote the use of common standards and procedures for handling security incidents, and to co-ordinate joint initiatives, including training for security staff (Géant, 2020[8]).

- In **the Netherlands**, SIVON (a co-operative of school boards) together with SURF entered an agreement with Google on behalf of education institutions to ensure that Google does not use data collected through Google services and Chromebooks from schools and students for its own purposes (SIVON, 2022[38]).

In addition, such networks, associations and co-operatives have also emerged as providers of security services for education institutions:

- In **Australia**, AARNet (Australian Academic and Research Network) provides connectivity and security services to K-12 schools and research communities across the country (AARNet, n.d.[39]). Services offered include education roaming, private cloud connections or virtual private networks. AARNet is run by a not-for-profit company that is owned by Australian Universities and the government's research agency (AARNet, n.d.[40]).
- In **Europe,** NRENs increasingly play a role in cyber security through network monitoring, specialist support when an institution comes under attack, and providing a vital source of advice and notification, both on emerging threats and immediate actions. In fact, most NRENs in Europe have some kind of security audit of their organisation (Géant, 2020[8]). Given the considerable investment needed, only the largest NRENs in Europe have started moving their security services to security operations centres. Moreover, Géant offer shared security services to NRENs including a Trusted Certificate Service (used by 33 NRENs in 2020), a Firewall on Demand (used by 28 NRENs) and eduVPN a state of the art, privacy-preserving VPN service (Géant, 2020[8]).

Support the development of policies, standards, or guidelines for monitoring algorithm and AI use and impact in education

Regulations surrounding the use of algorithms and AI in education are not yet widespread in OECD and EU countries, although there are emerging efforts to regulate their use more broadly (e.g. the Algorithmic Accountability Act of 2022 proposed in the **United States**). Education is a critical area of application for AI and algorithm-based tools, with a 36% estimated growth expected in the size of the education AI market between 2022 and 2030 (Grand View Research, 2021[41]). Against the background of growing concerns on the impact of algorithm bias in education, the increasing uptake of these new technologies must be matched by new regulatory efforts.

Some efforts have already been made to set guidelines for AI in more general terms, such as the OECD AI principles described in Box 4.1. While the development of general regulations for AI and algorithm-based tools has a wider scope than the education sector, education sector stakeholders and experts must be engaged in the development of these legislations to ensure the specific needs of the education sector are met (Baker and Hawn, 2021[12]; Turner Lee, Resnick and Barton, 2019[42]; OECD, 2021[11]). Further efforts to support research on algorithmic bias in education are also needed, including support for improvements in data collections (particularly on underrepresented demographic groups in current research), additional funding for research and for designing education-specific tools to conduct bias audits (Baker and Hawn, 2021[12]).

Beyond participating in government-level regulation of the use of AI and algorithm-based tools, educators must be further empowered to use these education technologies responsibility and carefully and to critically question their implications on privacy and fairness. This requires formulating and disseminating guidelines for the application of AI and algorithm-based tools in education. There are first indications for efforts in this field, both on an international and national level:

- In **Europe**, the European Commission has recently provided ethical guidelines on the use of AI and data in teaching and learning (European Commission, 2022[43]). The guidelines aim to inform educators about the potential of AI applications for education and raise awareness of possible risks.

- In March 2023, the Department of Education in the **United Kingdom** released a policy position paper on the use of generative AI in education systems, highlighting the responsibilities of schools, colleges, universities and awarding institutions to avoid malpractice using the technology and to continue to ensure that data is protected (Department for Education, 2023[44]). At the same time, the paper highlights the potential for generative AI to reduce workload across the education sector, and free up staff time to focus on delivering excellence in teaching.

Box 4.1. OECD AI principles

The OECD AI principles set international standards for innovative and trustworthy AI which respects human rights and democratic values. Since their adoption as part of the OECD Council Recommendation on Artificial Intelligence in 2019, all OECD member countries as well as Argentina, Brazil, Egypt, Malta, Peru, Romania, Singapore and Ukraine have signalled their political commitment to the following principles:

- AI should drive inclusive growth, sustainable development and well-being.
- AI systems should be designed to respect the rule of law, human rights, democratic values and diversity and should include appropriate safeguards towards this end.
- There should be transparency and responsible disclosure around AI systems.
- AI systems must function in a robust, secure and safe way throughout their life cycles and potential risks should be continually assessed and managed.
- Organisations and individuals developing, deploying or operating AI systems should be held accountable for their proper functioning in line with the above principles.

Consistent with these value-based principles, the OECD also provides recommendations to governments related to facilitating investments into R&D in AI, creating an adequate policy environment for trustworthy AI systems or ensuring equitable access to AI ecosystems. Whilst the OECD AI principles are not limited to the education sector, they provide an example of internationally agreed standards that countries might want to adhere to when designing education-specific guidance and regulation for the use of AI.

Source: OECD (2019[45]), *The OECD Artificial Intelligence (AI) Principles - OECD.AI*, https://oecd.ai/en/ai-principles (accessed on 31 May 2023).

Develop policies that support interoperability of technologies and portability of data

A lack of interoperability of digital technologies used in schools and higher education institutions creates administrative and operational inefficiency, elevates the risk of vendor lock-in and hampers capacity to develop performance and learning analytics. Governments may act on a number of fronts to support interoperability of digital technologies within and across individual institutions and education systems.

Interoperability can be improved through greater use of open standards for digital education technologies. Governments and education stakeholders have a role to play in both developing and encouraging the adoption of open standards. For maximum efficiency and utility, and to increase the likelihood of their widespread adoption, standards may be most usefully established at international level, through collaborative networks of national education stakeholders and experts. In **Europe**, examples of notable initiatives to develop open standards for education technologies include the standards developed by 1Edtech (formerly IMS Europe, a subgroup of IMS Global Learning Consortium) which cover learning platforms, learning data and analytics, integrated assessment tools and standards (1Edtech, n.d.[46]) and the standards of the Europass Digital Credentials Infrastructure for issuing and sharing evidence of learning undertaken in European education systems (European Union, n.d.[47]).

Education institutions and educators may also require support to ensure the interoperability of various tools. Given that education institutions in some systems have already widely adopted LMS (Brown, Millichap and Dehoney, 2015[48]), ensuring that new technological tools can be integrated into the most widely used LMS can help to make them available to educators in a cost-effective manner and at scale.

Governments can also inform and encourage education institutions to commit to open standards and embed interoperability as a core criterion when adding to or upgrading their individual technology stacks. For example, procedures for school inspections and quality assurance evaluations of HEIs could include reflection on the extent to which technologies in use are interoperable and aligned with open standards. Governments can also facilitate knowledge-sharing about the importance of open technologies, and support platforms for institutions to share strategies and practices that successfully break down data silos and enhance interoperability. Finally, public authorities can explore ways to standardise the technologies in use across institutions as much as possible, to minimise interoperability challenges – for example by supporting large-scale procurements of technologies, or by directly providing or encouraging the use of software that adheres to open standards.

Interoperability frameworks have already been designed and developed in some education systems, as a means to improve the effectiveness and efficiency of digital education technologies. Examples include:

- The National Schools Interoperability Program (NSIP) in **Australia** promotes common technical standards and supports aiming to improve the interoperability of information systems used by schools and school authorities across Australia. A Steering Group comprising national, state and territorial education authorities oversees the work, and a small group of professionals work continuously on the project, engaging schools, standard-setting bodies and EdTech firms. It supports the widespread adoption of the Systems Interoperability Framework (SIF), an open standard used to link individual data systems in the school sector. The SIF has also been widely adopted in the UK and the USA (NSIP, n.d.[49]).
- In **Germany**, the Federal Ministry of Education and Research is funding the development of a digital education platform or hub to integrate education platforms at the national level. A network of university, civil society and business stakeholders is supporting the project that builds on previous experiences with interoperable solutions in the higher education sector. One of the prototypes developed as part of the project will enable testing structures for data exchange and interoperability of different platform types, while accounting for the federal structure of the German education system (BMBF, 2021[50]).
- In **Portugal**, the “IES+ Perto” project brought together four Portuguese higher education institutions, in collaboration with the Portuguese NREN and the Portuguese National Security Office to develop a range of technologies to improve interoperability, including a common cloud infrastructure (cloud4IES) and an interoperability platform (PI4IES) that standardises communications with the diverse administration systems in each institution, allowing for seamless transfer of students between institutions and simplified administration of jointly delivered programmes (IES+Perto, 2016[51]).

Design quality assurance policies that support the effective use of digital technologies in teaching

Education systems need to develop a coherent quality assurance approach to digital education, as the use of digital technologies continues to expand in education systems. Incorporating a digital education dimension in quality assurance processes can support a more effective integration of digital technologies in teaching and learning.

School education systems rely on a range of quality assurance tools, including school self-evaluations, external evaluations, teachers and school leaders' appraisal, student standardised assessments and national qualifications/exams (European Commission, 2018[52]). Self-evaluation tools (e.g. the SELFIE tool developed by the European Commission) or a focus on digital technologies in external evaluation frameworks (European Commission/EACEA/Eurydice, 2019[18]) offer new avenues for monitoring and improving the use of digital technologies at the school level.

- With respect to the evaluation of education institutions themselves,
  - Already before the pandemic, in **Spain**, the Autonomous Community of Castilla y León included a comprehensive list of digital education-related indicators in its external school evaluation framework in order to evaluate the integration of digital technologies in teaching and learning activities (European Commission/EACEA/Eurydice, 2019[18]).
  - In **Ireland**, the implementation of the revised Digital Strategy for Schools to 2027 will include ongoing development of measurement and assessment mechanisms at the system level, combined with support for school self-evaluations and for teachers as part of their practices (Department of Education Ireland, 2022[53]). Prior to the revised Digital Strategy, some evaluation models in Ireland already enabled inspectors to assess schools' integration of digital technologies, for instance by examining whether schools relied on the Digital Learning Framework or had a Digital Learning Plan (European Commission/EACEA/Eurydice, 2019[18]).
- But quality assurance efforts also focus on the more granular level or actual digital education technologies. For instance in **Austria**, the 8-Point Plan for Digital Learning (launched in 2020 to support the goals of the pre-existing digital education strategy) includes a "Quality mark for learning apps" with the objective of encouraging an expansion in the availability of quality digital education resources and content (BMBWF, 2020[54]). Such apps will be subject to reviews and certification based on a range of criteria (education-related, ease of use, data privacy, etc.).

Given the diversification and multiplication of evaluation and assessment tools and methods, education systems need to ensure synergies among them to provide a coherent and consistent approach (OECD, 2013[55]). Building a coherent quality assurance approach for digital education therefore requires articulations between the different components of evaluation and assessment frameworks. In addition, capacity for quality assurance also needs to be built across education institutions, from teachers performing assessments of learning with digital technologies at the classroom level to school leaders or education administrators who rely on data to monitor, understand and assess the outcomes of education.

Quality assurance agencies should develop quality standards and guidance to inform higher education institutions to make innovative use of digital technologies, based on transnational guidance

In higher education systems, as mentioned previously, many institutions and governments base their quality assurance policies for digital education on guidance and standards produced by transnational organisations. The most recent ENQA Working Group "Considerations for the quality assurance of e-learning provision" (Huertas et al., 2018[22]) are not legally binding for quality assurance agencies and institutions operating in the EHEA, but propose a set of indicators that can be used to evaluate e-learning provision across each of the ten standards and guidelines of the ESG (Staring et al., 2022[56]). Quality assurance bodies and institutions may also draw on other international frameworks that provide indicators and methods for the quality assurance of digital higher education.

Following the guidance from transnational bodies, such as the common European approach to the quality assurance of digital higher education, national quality assurance bodies should seek to adopt quality standards and guidelines for digital higher education that can guide institutions to make innovative use of digital technologies. First, national quality assurance bodies should work with higher education stakeholders to develop a shared vocabulary for digital learning, informed by international frameworks, that builds common understanding and trust among higher education stakeholders and permits productive discussions about the scope for digital innovation in their higher education system.

- **Malta's** and **Romania**'s guidelines for digital higher education, for instance, both provide definitions for the wide variety of terms associated with digital learning (Malta Further and Higher Education Authority, 2021[57]; ARACIS, 2020[29]).
- In the **UK**, the Quality Assurance Agency for higher education has developed a *Taxonomy for Digital Learning* to "support providers to develop their ways of talking about digital methods of delivery, articulating what students can expect and therefore better assure themselves that quality and standards are being maintained" (QAA, 2020[58]).

Secondly, quality assurance agencies should collaborate with institutions to develop shared standards, indicators and methods for digital provision, covering all types of digitally enhanced education. Drawing upon leading international practice and national quality standards for digital higher education, potential indicators could be considered for the quality assurance of the following domains: institutional strategy for e-learning; digital education infrastructure, digital course design, delivery and assessment; staff professional development; student support and feedback; and monitoring and evaluation of outcomes.

- An example of a system that has developed national standards and guidelines in collaboration with the higher education sector is **Ireland**. In 2018 Quality and Qualifications Ireland (QQI) developed *Statutory Quality Assurance Guidelines for Providers of Blended Learning Programmes* (QQI, 2018[59]). In February 2022, QQI launched a call for tenders to revise the existing guidelines and expand their scope to fully online programmes.

Ongoing modernisation of quality assurance systems, across Europe in particular, can also support the development of new approaches for the quality assurance of digital education. Across Europe, many countries have been adapting their quality assurance systems in line with the European Commission's *Council Recommendation on building bridges for effective European higher education cooperation*, which states quality assurance systems should seek to "move further towards the use of institutional-based external quality assurance" and "allow for self-accreditation of programmes" (European Commission, 2022[60]).

- For example, **Hungary** is in the process of revising its programme accreditation procedures to make it easier for HEIs to launch new programmes, including in fully online and hybrid formats. Up to recently, Hungary's quality assurance system was characterised by heavy ex-ante programme accreditation procedures, based on a strict separation of programme types (full-time, part-time and distance learning) that have strict requirements on how these programmes are to be delivered by HEIs (Hungarian Ministry, 2011[61]). Ongoing reforms to the accreditation process are intended to support student choice and flexible learning, including the integration of digital study components such as asynchronous online learning into study programmes (OECD, 2023[62]).

Key messages

Digital education exposes learners to a variety of risks. Beyond the possible adverse effects of digital technologies on mental and physical well-being (e.g. extended screen time), these risks may also impact learners' human rights and children's' rights (e.g. inequitable access to education opportunities or data protection). Uses of advanced technologies such as AI in education contexts further amplify these concerns and call for regulatory efforts to protect learners in digital learning environments.

Currently, little specific regulation exists on the protection of learners in digital environments across OECD and EU countries. While broader regulatory frameworks – such as the GDPR – have implications for education institutions, more guidance and support are needed to empower education institutions to comply with these regulations. Specific regulations and guidance on the use of AI in education settings also remain largely absent from OECD and EU education systems.

The use of digital technologies also poses challenges on an institution level. For instance, the increasing use of digital learning tools makes education institutions more prone to cyber security threats. Some countries have promoted cyber security services specifically tailored to the needs of education institutions. Similarly, the broad variety of hardware and software used in education call for efforts to support interoperability of different tools to remove barriers to access to learning opportunities.

Beyond managing the challenges and risks associated with digital education, policy makers must assure the quality of digital infrastructure and pedagogies. Conventional quality assurance mechanisms – such as external evaluations or self-evaluation tools – must therefore be adapted to include aspects of digital education. Whilst the analysis in this chapter highlights that digital education is increasingly covered in quality assurance tools across OECD and EU countries, more attention needs to be paid to identify the relevant aspects of digital education which should be included in quality assurance frameworks.

References

1Edtech (n.d.), *Learning Tools Interoperability*, https://www.imsglobal.org/activity/learning-tools-interoperability. [46]

AARNet (n.d.), *Connectivity and collaboration services for K-12 schools*, https://www.aarnet.edu.au/k-12-schools (accessed on 12 April 2023). [39]

AARNet (n.d.), *Our Governance*, https://www.aarnet.edu.au/governance (accessed on 12 April 2023). [40]

ARACIS (2020), *Methodology and Guidelines on External Quality Evaluation in Higher Education in Romania. Part VI: Specific Standards and Guidelines on External Evaluation of the Quality of Distance Learning (DL) and Part-Time Learning (PTL) Degree Programmes*, ARACIS, Bucharest, https://www.aracis.ro/wp-content/uploads/2021/11/Result-1.-Part-VI-METHODOLOGY-DISTANCE-LEARNING-EN.pdf. [29]

Baker, R. and A. Hawn (2021), "Algorithmic Bias in Education", *Centre for Open Science*, https://doi.org/10.35542/OSF.IO/PBMVZ. [12]

BMBF (2021), *Erstes Pilotprojekt für Nationale Bildungsplattform startet - BMBF*, https://www.bmbf.de/bmbf/de/home/_documents/erstes-pilotprojekt-fuer-nationale-bildungsplattform-startet.html (accessed on 31 August 2022). [50]

BMBWF (2020), *Digitale Schule*, https://digitaleschule.gv.at/ (accessed on 5 December 2022). [54]

Bonefeld, M. and O. Dickhäuser (2018), "(Biased) Grading of Students' performance: Students' names, performance level, and implicit attitudes", *Frontiers in Psychology*, Vol. 9/MAY, p. 481, https://doi.org/10.3389/FPSYG.2018.00481/BIBTEX. [13]

Brown, M., N. Millichap and J. Dehoney (2015), "What's Next for the LMS?", *EDUCAUSE Review*, Vol. 50/4, https://er.educause.edu/articles/2015/6/whats-next-for-the-lms (accessed on 6 May 2022). [48]

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. [5]

Casovan, A. and V. Shankar (2022), *A framework to navigate the emerging regulatory landscape for AI - OECD.AI*, OECD. AI Policy Observatory, https://oecd.ai/en/wonk/emerging-regulatory-landscape-ai (accessed on 26 June 2022). [15]

CMS (n.d.), *GDPR Enforcement Tracker - list of GDPR fines*, https://www.enforcementtracker.com/ (accessed on 22 June 2022). [9]

Department for Education (2023), "Generative artificial intelligence in education", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1146540/Generative_artificial_intelligence_in_education_.pdf (accessed on 12 April 2023). [44]

Department for Education (2019), "Realising the potential of technology in education: A strategy for education providers and the technology industry". [33]

Department of Education Ireland (2022), *Digital Strategy for Schools to 2027*, https://www.gov.ie/en/publication/69fb88-digital-strategy-for-schools/#digital-strategy-for-schools-to-2027 (accessed on 26 August 2022). [53]

E4 Group (2015), *Standards and Guidelines for Quality Assurance in the European Higher Education Area (ESG)*, European Association for Quality Assurance in Higher Education; European Students' Union; European University Association; European Association of Institutions in Higher Education, http://www.enqa.eu/wp-content/uploads/2015/11/ESG_2015.pdf. [20]

Eduscol (2022), *Le référentiel CNIL de formation des élèves à la protection des données personnelles*, https://eduscol.education.fr/574/le-referentiel-cnil-de-formation-des-eleves-la-protection-des-donnees-personnelles (accessed on 27 June 2022). [30]

EUR-Lex (2016), *Document 32018R1725*, https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1552577087456&uri=CELEX:32018R1725 (accessed on March 2022). [6]

European Commission (2022), *Ethical guidelines on the use of artificial intelligence (AI) and data in teaching and learning for educators - Publications Office of the EU*, https://op.europa.eu/en/publication-detail/-/publication/d81a0d54-5348-11ed-92ed-01aa75ed71a1/language-en (accessed on 26 January 2023). [43]

European Commission (2022), *Proposal for a Council Recommendation on building bridges for effective European higher education cooperation*, European Commission, Brussels, https://education.ec.europa.eu/document/proposal-for-a-council-recommendation-on-building-bridges-for-effective-european-higher-education-cooperation (accessed on 24 June 2022). [60]

European Commission (2022), *The European Interoperability Framework in detail*, https://joinup.ec.europa.eu/collection/nifo-national-interoperability-framework-observatory/european-interoperability-framework-detail (accessed on March 2022). [16]

European Commission (2018), *etter learning for Europe's young people : developing coherent quality assurance strategies for school education : report from an expert assignment*, https://data.europa.eu/doi/10.2766/86303 (accessed on 23 February 2023). [52]

European Commission/EACEA/Eurydice (2019), *Digital Education at School in Europe*, Eurydice Report. Luxembourg: Publications Office of the European Union, https://eacea.ec.europa.eu/national-policies/eurydice/content/digital-education-school-europe_en (accessed on 4 August 2020). [18]

European Union (n.d.), *Europass digital credentials*, https://europa.eu/europass/digital-credentials/issuer/#/home. [47]

FELVI (2021), *Statistics from the past years of applications and acceptence (2001-2021*, https://www.felvi.hu/felveteli/ponthatarok_statisztikak/elmult_evek/!ElmultEvek/index.php/elmult_evek_statisztikai/munkarendenkent (accessed on March 2022). [26]

Gaebel, M. et al. (2021), "DIGITALLY ENHANCED LEARNING AND TEACHING IN EUROPEAN HIGHER EDUCATION INSTITUTIONS", http://www.eua.eu (accessed on 7 December 2021). [25]

Géant (2020), *Compendium of National Research and Education Networks in Europe - 2020*, https://about.geant.org/wp-content/uploads/2021/12/Compendium_FINAL2.pdf. [8]

GOV.UK (2021), *Quality assuring providers of full-time online education*, https://educationinspection.blog.gov.uk/2021/11/24/quality-assuring-providers-of-full-time-online-education/ (accessed on 1 September 2022). [19]

Grand View Research (2021), *AI In Education Market Size & Share Report, 2022-2030*, https://www.grandviewresearch.com/industry-analysis/artificial-intelligence-ai-education-market-report/methodology (accessed on 26 January 2023). [41]

Holmes, W. et al. (2022), "Artificial Intelligence and Education: A critical view through the lens of human rights, democracy and the rule of law", http://book.coe.int (accessed on 7 April 2023). [10]

Huertas, E. et al. (2018), *Considerations for quality assurance of e-learning provision*, European Association for Quality Assurance in Higher Education, Brussels, https://www.aqu.cat/elButlleti/butlleti91/articles2_en.html#.YGY_R5NKhTZ (accessed on 22 December 2021). [22]

Hungarian Ministry (2011), *Act CCIV of 2011 on National Higher Education*. [61]

IES+Perto (2016), *IES+Perto project results*, https://iesmaisperto.up.pt/?page_id=147. [51]

INQAAHE (2022), "International Standards and Guidelines for Quality Assurance in Tertiary Education 2022 Edition © International Network for Quality Assurance Agencies in Higher Education", https://www.inqaahe.org/sites/default/files/INQAAHE-International-Standards-and-Guidelines-ISG.pdf (accessed on 19 February 2023). [23]

INQAAHE (2018), *Guidelines of Good Practice*, International Network for Quality Assurance Agencies in Higher Education (INQAAHE), Barcelona, https://www.inqaahe.org/guidelines-good-practice (accessed on 10 January 2022). [21]

International Working Group on Digital Education (2016), "Référentiel de Formation des élèves à la protection des données personnelles". [31]

Malta Further and Higher Education Authority (2021), *Guidelines for Quality Assurance - For Online Learning Providers in Malta*, Malta Further and Higher Education Authority, Valletta, https://mfhea.mt/wp-content/uploads/2021/10/Guidelines-for-FHEI-V1.pdf (accessed on 2 August 2022). [57]

Ministère de l'éducation nationale (n.d.), *Le Gestionnaire d'Accès aux Ressources (GAR)*, https://eduscol.education.fr/213/gestionnaire-d-acces-aux-ressources (accessed on 3 April 2023). [32]

NCSC (2021), *Cyber Security for Schools*, https://www.ncsc.gov.uk/section/education-skills/cyber-security-schools (accessed on 27 June 2022). [34]

Netjogtar (2022), *Updated Government Decrees*, https://net.jogtar.hu/. [27]

NSIP (n.d.), *The National Schools Interoperability Framework*, https://www.nsip.edu.au/about-nsip. [49]

OECD (2023), *Advancing Digital Maturity in Croatia's Higher Education System*, OECD Publishing, Paris, https://doi.org/10.1787/26169177. [28]

OECD (2023), *Ensuring Quality Digital Higher Education in Hungary*, Higher Education, OECD Publishing, Paris, https://doi.org/10.1787/5f44fd6f-en. [62]

OECD (2022), *Companion Document to the OECD Recommendation on Children in the Digital Environment*, OECD Publishing, Paris, https://doi.org/10.1787/a2ebec7c-en (accessed on 1 September 2022). [4]

OECD (2021), "Children in the digital environment: Revised typology of risks", *OECD Digital Economy Papers,*, No. 302, OECD Publishing, Paris, https://doi.org/10.1787/9b8f222e-en (accessed on 1 September 2022). [2]

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. [11]

OECD (2021), *Recommendation of the Council on Children in the Digital Environment*, OECD Legal Instruments, https://legalinstruments.oecd.org/en/instruments/OECD-LEGAL-0389%20 (accessed on 28 June 2022). [36]

OECD (2021), *Supporting the Digital Transformation of Higher Education in Hungary*, Higher Education, OECD Publishing, Paris, https://doi.org/10.1787/d30ab43f-en. [37]

OECD (2020), "Protecting children online : An overview of recent developments in legal frameworks and policies", *OECD Digital Economy Papers*, No. 295, OECD Publishing, Paris, https://doi.org/10.1787/9e0e49a9-en (accessed on 27 June 2022). [1]

OECD (2019), *The OECD Artificial Intelligence (AI) Principles - OECD.AI*, https://oecd.ai/en/ai-principles (accessed on 31 May 2023). [45]

OECD (2013), *Synergies for Better Learning: An International Perspective on Evaluation and Assessment*, OECD Reviews of Evaluation and Assessment in Education, OECD Publishing, Paris, https://doi.org/10.1787/9789264190658-en. [55]

Perry, A. and N. Turner-Lee (2019), *AI can disrupt racial inequity in schools, or make it much worse*, https://hechingerreport.org/ai-can-disrupt-racial-inequity-in-schools-or-make-it-much-worse/ (accessed on 31 May 2023). [14]

QAA (2020), *Guidance Building a Taxonomy for Digital Learning*, Quality Assurance Agency for Higher Education (QAA), London, https://www.qaa.ac.uk/docs/qaa/guidance/building-a-taxonomy-for-digital-learning.pdf (accessed on 31 July 2020). [58]

QQI (2018), *Statutory Quality Assurance Guidelines for Providers of Blended Learning Programmes*, Quality and Qualifications Ireland (QQI), Dublin, https://www.qqi.ie/sites/default/files/media/file-uploads/Statutory%20QA%20Guidelines%20for%20Blended%20Learning%20Programmes.pdf (accessed on 8 December 2021). [59]

République Française (2020), *Référentiel général d'interopérabilité (RGI)*, https://www.numerique.gouv.fr/publications/interoperabilite/ (accessed on 2022). [17]

Ruohonen, J. and K. Hjerppe (2022), "The GDPR enforcement fines at glance", *Information Systems*, Vol. 106, p. 101876, https://doi.org/10.1016/J.IS.2021.101876. [7]

SIVON (2022), *SIVON behartigt belangen schoolbesturen*, https://www.sivon.nl/sivon-behartigt-belangen-schoolbesturen/ (accessed on March 2022). [38]

Staring, F. et al. (2022), *Digital higher education: Emerging quality standards, practices and supports*, https://www.oecd.org/education/digital-higher-education-f622f257-en.htm. [56]

Tait, A. (2022), *ICDE Quality Network report 2021: Global Quality Perspectives on Open, Flexible and Distance Learning 2021 — ICDE*, ICDE, Oslo, https://www.icde.org/knowledge-hub/icde-quality-network-report-2021 (accessed on 24 June 2022). [24]

Turner Lee, N., P. Resnick and G. Barton (2019), *Algorithmic bias detection and mitigation: Best practices and policies to reduce consumer harms*, https://www.brookings.edu/research/algorithmic-bias-detection-and-mitigation-best-practices-and-policies-to-reduce-consumer-harms/#footref-38 (accessed on 26 January 2023). [42]

UNICEF (2022), *Child Online Protection in and through Digital Learning*, UNICEF Regional Office for Europe and Central Asia (ECARO). [3]

US Department of Education (n.d.), *Protecting Student Privacy*, https://studentprivacy.ed.gov/ (accessed on 12 April 2023). [35]

Notes

[1] The *standards* are defined as “agreed and accepted practice for quality assurance in higher education in the EHEA”; the *guidelines* explain “why the standard is important and describe how standards might be implemented”, setting out examples of good practice (E4 Group, 2015, p. 9[20]).

5 Funding and procurement for digital education

This chapter highlights current challenges related to the funding and procurement of digital education technologies. Policy makers in many countries have limited information available when making investment decisions, and the funding environment for digital education technologies is fragmented, creating planning and budgeting difficulties for education institutions. The chapter presents a number of promising approaches that countries have used to address these challenges by adapting funding and revenue models to the specificities of digital education and by building collective capacity across education institutions to make smarter investments in digital technologies.

Introduction

Digital education entails large investments in the physical and human infrastructure of education institutions. This chapter focuses on how funding and procurement mechanisms must be rethought to enable efficient and equitable investments for digital education. As such, this chapter lays the foundation for infrastructure, capacity building and human resource policies described in subsequent chapters.

In general, smart education investments require a fundamental understanding of the flow of resources and the effects specific investments yield on education outcomes. With respect to digital education, large knowledge gaps persist on the extent of investments in digital technologies within education systems, although there is some evidence suggesting that public spending levels are currently insufficient to cover institutions' funding needs. There are also mixed research findings regarding the cost-efficiency of investments in digital education, calling for well-considered and evidence-based spending on digital education. Raising the necessary information to guarantee sufficient and efficient investments in digital education might entail adapting institutional budgeting and accounting practices as well as promoting better evaluation of digital education policies.

Further, Institutional funding frameworks need to provide education institutions with the resources they need for the acquisition and deployment of digital education technologies, in line with policy objectives. To do so effectively, institutional funding models may need to evolve and adapt to the particularities of digital education technologies. This could include, for example, permitting the inclusion of new modes of education participation (e.g. enrolment in online or hybrid education programmes) for core institutional funding and student aid. Funding allocation mechanisms may also need to be adapted to the specific nature of investments in digital technologies, which often comprise a mix of upfront capital investments and recurrent expenditure. Funding frameworks should further seek to address potential equity issues in access to digital education technologies and take into account existing governance and decision-making arrangements related to digitalisation within different education sectors.

Finally, effective procurement for digital education requires a forward-looking approach and a deep understanding of the complex EdTech sector. Individual education institutions often lack the necessary expertise or bargaining power to make efficient investments in digital education. Depending on education institutions' role in the procurement process, governments may need to provide guidance and tools to support institutions' procurement decisions or ensure that efficient central procurement mechanisms are in place.

The funding and procurement of digital education technologies raises a number of questions for policy makers, which this chapter seeks to address by taking stock of the available evidence and presenting promising approaches observed in OECD and EU countries:

- How much do school and higher education systems invest in digital education technologies and is current investment sufficient to cover education institutions' needs?
- How can education systems promote efficiency in spending on digital education?
- Are institutional funding framework adapted to new modes of teaching and learning enabled by digital education technologies?
- Are education institutions enabled and incentivised to invest in digital technologies in line with their students' needs as well as system-wide goals?

Recent developments and current challenges

Comparative data on digital education investments and evidence of their efficiency remain limited

Institutional accounting and budgeting practices do not permit the identification of public expenditure on digital education…

The joint UNESCO-OECD-Eurostat data collection, published annually in *Education at a Glance*, provides a wealth of internationally comparable data and indicators on education investments across countries and levels of education. These data show that across all education levels, education funding is mostly spent on current expenditure[1] (more than 90% on average across OECD and EU countries with available data), with the remainder being devoted to capital expenditure[2] (OECD, 2021[1]):

- In school education, across the OECD in 2018, the largest share of current expenditure in public and government-dependent private primary, secondary and post-secondary non-tertiary institutions was devoted to compensation of teaching and non-teaching staff (77%), with the remaining 23% dedicated to other operational expenditure (utilities and other service providers, supplies, day-to-day maintenance and equipment costs) (OECD, 2021[1]).[3]
- In higher education, in 2018, public and government-dependent higher education institutions in OECD countries with available data dedicated roughly one-third of their total spending to compensation of staff with a direct teaching role (i.e. most academic staff), one-quarter to compensation for support, professional and research staff, a further third to other operational expenditure (e.g. utilities, supplies, day-to-day maintenance and equipment costs) and around 10% to capital investment (major investments in infrastructure and equipment) (OECD, 2021[1]).

Evidence about expenditure devoted specifically to digital education is scarce. An OECD Digital Economy Policy Questionnaire administered in 2016 reveals that among the 38 OECD and partner countries surveyed, around 75% of governments reported allocating funds to ICT literacy objectives in state/national curricula and more than 70% reported buying ICT goods and services for students. The most frequent types of public expenditure on ICT in education were financial support for ICT equipment or Internet connections for public schools: around 50% of surveyed countries reported expenditure on these expenses. Policies for buying or developing digital learning materials (e.g. e-textbooks) were less common (reported by 25% of surveyed countries) (OECD, 2017[2]).

Apart from ad-hoc and one-off data collections, no consolidated internationally comparative data exist to provide an overview of expenditure on digital technologies by education institutions at various levels of education, or by governments. A 2019 survey of European countries revealed the difficulty of identifying the actual government funds invested in digital infrastructure for school education (European Commission/EACEA/Eurydice, 2019[3]) (European Commission/EACEA/Eurydice, 2019[3]).

Part of the difficulty lies in the fact that accounting and financial reporting systems are not designed to identify different types of expenditure that support digital learning. As expenditure related to digital education often comprises a mix of capital spending and current expenditure (e.g. software product purchases, staff costs and technology-related services), it tends to be grouped with other expenditure of a similar type that is unrelated to digital education. In this context, it is not possible to rely on government budget's line items to track digitalisation spending.

Likewise, the budgets of education institutions usually do not categorise their spending on digital infrastructure separately within their accounting systems. For instance, the UNESCO-OECD-EUROSTAT (UOE) data collection on expenditure in education institutions, which is reported annually in Education at a Glance, covers expenditure on digitalisation, but most spending on digitalisation is integrated into capital expenditure or the category of "expenditure on other resources", which includes the purchase of teaching and learning materials, other materials and supplies, equipment items not classified as capital, fuel, electricity, telecommunications, travel expenses, and insurance. The level of granularity in reporting is thus insufficient to identify expenditure related specifically to digital infrastructure.

Special efforts have been made to create spending estimates in some countries:

- For example, in **Ireland** a review of technical higher education infrastructure detailed the difficulty of arriving at an estimate of expenditure on IT within the current accounting practices, concluding that expenditure on IT in the region amounted to 4% of the non-pay budget (National Forum for the Enhancement of Teaching and Learning in Higher Education, 2017[4]).
- Data from the **United States** (Educause, 2022[5]) indicate that median spending per full-time equivalent student on central IT services in public and private higher education institutions was around USD 1 300 in 2020/21. However, these figures only capture part of total spending on digital learning, as they exclude expenditure on staff time, at department and faculty level.

Whilst data on public spending on digital education are hard to obtain, estimates from the private sector can give some idea of digital education spending. Market estimates indicate that while global expenditure by governments, employers and consumers on hardware, software and technology-enabled services has intensified, it continues to represent only a small share (4%) of global spending on education and training (HolonIQ, 2020[6]; HolonIQ, 2021[7]). Other estimates from market research companies in the **United States** provide an indication of the amounts spent by education institutions on digital technologies in some countries. There, the share of expenditure in central IT departments of HEIs was estimated to be 4.2% in 2021, with a median expenditure of USD 7.7 million (USD 1 316 per student) (Educause, 2022[8]). With respect to school education, the median public district among the 77 largest urban public school systems in the United States spent around 2% of its budget on network services, computers and devices, technical support, systems and software (Council of the Great City Schools, 2020[9]).

… but expenditure levels on digital education are likely insufficient

There is limited evidence on the funding needs of schools and higher education institutions on digital education, although TALIS data suggest that a significant proportion of schools are struggling with a lack of resources for digital education. Prior to the pandemic, in 2018, 25% of lower secondary principals in OECD countries reported that shortages or inadequacy of digital technology for instruction were hindering their schools' capacity to provide quality instruction "quite a bit" or "a lot" (OECD, 2019[10]). This was confirmed by lower secondary teachers, 35% of whom reported that investing in ICT was a spending priority "of high importance" across OECD countries (34% across participating EU countries). The situation varied across countries though. Overall, ICT investment was perceived as a high priority by more than half of lower secondary teachers in Israel, Hungary, Mexico and Colombia, but by one out of five or less in Finland, Denmark, Sweden and Slovenia (OECD, 2019, p. 207[10]).

Various studies in Europe have also identified a need for additional investment to support the expansion of digital learning in higher education (EUA, 2021[11]), but there have been few attempts to quantify the investment requirements. One example of an effort to quantify investment needs comes from **Germany**. A 2019 report by Germany's national Commission of Experts for Research and Innovation argued that the "digitalisation of Germany's structurally underfinanced higher education system is an ongoing task which requires long-term financing" and proposed the introduction of a specific public funding allocation per student to develop and maintain digital infrastructure and expand digital teaching and learning offerings (EFI, 2019[12]). In 2021, the German Rectors' Conference adopted this proposal in a funding request to the federal and state governments, calculating, bottom-up, an annual funding requirement of EUR 92 per student (EUR 270 million in total), of which 40% would be dedicated to the development of digital learning offerings (including adapted learning spaces and new online courses, such as micro-credentials), 30% to services to support digital learning and 30% to purchasing and maintaining related infrastructure (HRK, 2021[13]). However, in general, there have been few studies of the cost of digital higher education provision (and whether it leads to cost savings elsewhere) which could be used as a basis to quantify investment requirements (OECD, forthcoming).

Available evidence suggests that not all investments in digital education are cost-efficient

The lack of information on expenditures on digital education technologies means that assessing efficiency of investments is challenging. Existing research indicates that the cost saving potential of digitally enhanced education may be limited, at least in the short term. For instance, recent experimental research demonstrates that education software has higher fixed and maintenance costs than conventional teaching tools, while the marginal costs are at a similar level (Ma et al., 2020[14]). The cost differential between technology and traditional tools calls for evidence on the effects of digital technologies on education outcomes to ensure efficient investments. Further analyses on the costs and benefits of digital education, would allow for better-informed investment in and allocation of digital technologies in education systems. Evidence from the experimental and quasi-experimental evaluation literature suggests that programmes investing in digital education equipment and connectivity have been successful in expanding access to computers, and also resulted in higher levels of computer use and skills (Escueta et al., 2017[15]). These patterns hold across a range of policy intervention types (e.g. subsidies for low-income families to acquire computers, one-to-one-laptop or tablet programmes, and subsidies for school computers). However, simply expanding access to digital resources (e.g. computer hardware or Internet access) is insufficient to enhance students' *academic performance*. Substantial research evidence shows that increases in digital infrastructure investments in the form of computers, laptops, tablets or Internet access for schoolchildren display little or no positive effects on students' education outcomes (Bulman and Fairlie, 2016[16]; Escueta et al., 2017[15]).

Research on the impact of education software use on student outcomes suggests that multi-dimensional policies – including the expansion of access to digital equipment and connectivity, the introduction of specific learning tools or interventions, and policies addressing the wider learning ecosystem (e.g. guidelines or support for parents, building teachers' digital pedagogy skills) – are most effective. Evidence from the COVID-19 pandemic has shown that even where gaps in access to equipment were bridged and students from socio-economically disadvantaged schools received the necessary equipment to engage in remote learning, inequalities in how students *use* these tools and the level of their engagement with the equipment persisted (NESTA, 2021[17]). Thus, policies that target divides in access to digital equipment should go hand in hand with building the capacity of users and the broader learning ecosystem. Chapter 7 on building capacity for digital education analyses these aspects in more depth.

In higher education, available evidence suggests that developing and delivering online programmes is not systematically less costly than developing and delivering on-campus programmes. Some studies find evidence of cost-efficiency potential. For example, an evaluation of the effects of hybrid teaching in engineering programmes in Russia undertaken by Chirikov et al. (2020[18]), have found that students in online courses achieve similar learning outcomes to those receiving traditional in-person instruction at substantially lower costs. Bowen et. al. (2013[19]) likewise implemented a randomised trial in which a statistics course was taught in-person and in a hybrid mode, with the use of cognitive tutors and feedback loops to guide hybrid learners through instruction in basic concepts. Learners in the hybrid course achieved learning outcomes equivalent to those receiving in-person instruction, and simulations carried out by the researchers indicated that since outcomes were not worse, the course may be delivered on line at lower cost (Bowen et al., 2013[19]). By contrast, Hemelt et al. (2018[20]) find, using programme-level data on US higher education programmes, only moderate cost reductions associated with online undergraduate programmes (and none for post-graduate programmes). Wolff, Baumol and Saini (2014[21]) and Xu and Xu (2019[22]) argue that online education has the potential for cost saving and added value for particular target groups, but note the challenges of achieving cost reductions within the constraints of current higher education staffing and governance models.

The question of the potential cost savings that can be achieved through adopting digital learning routinely emerges in policy discussions. In the **Netherlands**, for example, a recent government policy paper argued that increased deployment of digital technologies in learning in higher education would allow efficiency gains, as well as quality improvements (Government of the Netherlands, 2021[23]). In response, commentators from the academic community have argued that using digital technology in learning and teaching typically requires more time – and thus higher costs – than traditional forms of classroom learning. The same commentators argue that digital learning technologies might enrich and support teaching but cannot replace or automate specific teaching-related tasks (van Baalen et al., 2021[24]).

However, the limited evidence base concerning the cost-efficiency of education investments is not a problem specific to digital education (OECD, 2022[25]). The use of cost-benefit and cost-effectiveness analyses in education is traditionally underdeveloped compared to other sectors (e.g. health). Previous research on this topic has highlighted a range of conceptual and measurement issues (e.g. related to the recording of costs in education systems) that make it difficult to generate cost-efficiency evidence and use it for policy making in the education sector (Hummel-Rossi and Ashdown, 2002[26]). However, although countries struggle to track investments in digital education, digital technologies also provide new opportunities to measure the effects of policy interventions in education: Digital education technologies can generate rich data that can – if employed effectively – provide valuable sources of evidence to assess the effects of using digital technologies and other classroom practices on student outcomes (OECD, 2013[27]).

Revenue-raising arrangements can generate inequities in the access to quality digital education technology

In OECD countries, schools and their digital education technologies are predominantly funded from public sources (90% in 2018), although the share of private funding is higher at the upper secondary education level (14%) (OECD, 2021[1]). Education systems across the OECD display a complex distribution of responsibilities for allocating funding across education sectors (OECD, 2017[28]). Most systems rely on a mix of central and sub-central funding for schools, with central government funding depending mostly on taxes while sub-central revenues are a typically a mix of taxes (own taxes and taxes shared with other government tiers) and transfers from more central government levels (OECD, 2017[28]).

Sub-central authorities increasingly engage in raising resources, allocating and managing school funding. While reliance on local tax revenues may enable better alignment between local preferences and needs and mobilising further resources for school education, it also risks creating inequities in funding across schools from different regions, states or localities, thereby requiring compensatory fiscal equalisation mechanisms to foster equity in and through digital education (OECD, 2021[29]). In addition, schools are also increasingly responsible over budgetary matters, which might result in higher inequities among schools if some schools lack the administrative capacity and preparation to deal with these budgetary responsibilities. However, little comparable information is available on the distribution of responsibilities for raising funds, allocating and managing resources related to digital education technologies in OECD or EU education systems.

The funding environment for digital learning in higher education differs substantially from that in the school sector. Funding and revenue models in higher education institutions vary across the OECD and within the EU. In 2018 – the most recent year for which consolidated international data are available – public funding sources accounted for an average of two-thirds (66%) of the revenue of higher education institutions in OECD countries, with a further 22% coming from tuition and fees paid by students (household expenditure) and the remaining 12% from a combination of other private and international funding sources (OECD, 2021[1]). Greater reliance on private sources of funding in higher education – including student fees in a number of countries – may also widen inequalities in access to available funding for investment in digital technologies.

Effective digital education requires a combination of current and capital expenditure

Digital education technology requires both current and capital expenditure. While the establishment of broadband connectivity and the acquisition of digital equipment require capital expenditure, other costs are likely to be recurring parts of education institutions' current expenditure, for example those for the professional development of education staff, the provision of technical support or the maintenance of hardware and software. To ensure efficient investments and a high quality of digital education, education systems need to allocate resources across both current and capital expenditures and strike the right balance between short-term and long-term investments.

The allocation between current and capital spending on digital education resources should reflect countries' digital education targets and their current state of digital education development. Striking this balance remains a challenge for many countries. When education institutions face trade-offs between current and capital expenditure, for example, there is a risk that long-term investments will be crowded out. Challenges can also arise when sub-central authorities or school leaders lack the capacity to assess the links between capital investments and maintenance funding (OECD, 2018[30]). In addition, the classification of some types of expenditure (e.g. for maintenance activities) as current or capital expenses, can be ambiguous (OECD, 2018[30]).

Education institutions receive funding for digital education through a range of allocation mechanisms

Although the overall level of investment in digital education matters, how funding is allocated and matched to learners' needs is equally crucial to promote access, equity, sustainability and efficiency. In school education, funds for education expenditure can be directed in several ways, depending on the type of expenditure (current and capital) and the discretion left to recipients (sub-central authorities and/or schools) on the use of the funding (OECD, 2017[28]; OECD, 2018[30]).[4]

Among OECD countries covered by the School Resources Review, for example, the most common allocation mechanisms for current expenditure at the school level funding include earmarked grants that require recipients to use the funding for specific purposes or items of expenditure, and block grants, which recipients can use to cover current expenditures at their own discretion. In the case of capital expenditure, the main allocation mechanisms include infrastructure investment programmes and ad-hoc grants.

Alongside their main funding allocation mechanisms, governments also rely on targeted programmes or grants that provide funding for specific purposes, education institutions, students or areas. During the COVID-19 pandemic, for example, a plethora of targeted programmes were implemented across OECD and EU countries to support access to Internet connection and digital devices for students from socio-economically disadvantaged backgrounds or rural areas.

The way in which funding for digitalisation is distributed – through the main allocation mechanisms or through targeted programmes – matters to ensure that funding reaches the education institutions and students who need it the most. While targeted programmes may be more flexible and responsive to changing priorities or emergency situations, a proliferation of targeted funding streams can lead to a lack of co-ordination, administrative efficiency and coherence, compared to the use, for example, of a central funding formula (OECD, 2017[28]; OECD, 2021[29]).

In higher education systems, public authorities nearly always transfer core operating funding to institutions as lump sums, without specifying the purpose of expenditure. Institutions pay for investments in digitalisation out of the lump sum budgets they receive, and government funders play no direct role in steering use of these funds. In higher education systems where governments use formula-based models to allocate funds to HEIs, one question relevant to digital learning is whether or not the formula used explicitly allocates funds for students enrolled or gaining credit in online programmes (and thus rewards and incentivises such provision). This appears to be the case in many OECD funding models for students enrolled in online versions of degree-awarding programmes (short-cycle, bachelor's and master's degrees) in mainstream publicly funded higher education institutions, although such students generally represent a small proportion of total enrolment.

In **Finland**, the core funding model, which is formula-driven and allocates a proportion of funding based on credits gained in continuous education (lifelong learning), is flexible enough to recognise credits gained in online programmes. Such programmes are, nevertheless, marginal in the overall volume of learning activities. More generally, formula-based allocation models usually consider only students enrolled or gaining credit in accredited programmes that lead to a recognised degree. Whether or not such funding-eligible degree programmes can be delivered fully on line typically depends on accreditation and other regulatory policies rather than public funding policies (SURF, 2016[31]).

A special case is the treatment in funding models of open universities, which have traditionally concentrated nearly all distance education in countries where they exist. In some systems, these institutions are funded outside the core funding model, usually with a lower level of allocation per student. This is the case for the (public) Open University in **Portugal** (*Universidade Aberta*). In other systems, such as **Scotland (United Kingdom)**, public funding for education is provided to the local Open University on largely the same basis as to mainstream, campus-based HEIs.

Leaving aside the specific case of open universities, the comparatively small numbers of students enrolled in online or hybrid programmes in publicly funded HEIs mean that that information and research on how public funding systems handle such students has been limited, at least prior to the pandemic. However, emerging evidence from the 2022 edition of the OECD Higher Education Policy Survey shows that students following hybrid bachelor's programmes are entitled to access public grants and loans under the same conditions as fulltime campus-based students in 26 of out 30 responding jurisdictions. For fully online students, the share of students eligible for supports on the same basis as on-campus students is lower (19 out of 30 jurisdictions).

In addition, examples of targeted government funding for digital learning based on specific, time-limited programmes, are widespread in OECD higher education systems. In **Germany**, for example, the Foundation for Innovation in Higher Education Teaching receives EUR 150 million annually from the federal and state governments to award to HEIs in competitive calls for learning innovation projects (Stiftung Hochschullehre, 2022[32]). In 2022, the National Growth Fund in the **Netherlands** awarded EUR 560 million to a multi-annual project jointly run by the associations of universities, universities of applied science, higher vocational institutions and the national collaborative ICT organisation SURF to support digital learning in post-secondary education (Digitaliseringsimpuls Onderwijs, 2022[33]). In 2021, the **French** government awarded EUR 100 million to 17 "digital demonstrator projects" (*Démonstrateurs numériques dans l'enseignement supérieur* – DemoES) to fund strategy development, infrastructure and pedagogical innovation in public higher education institutions across France (Government of France, 2021[34]).

A highly fragmented digital education ecosystem can lead to procurement and budgeting challenges for education institutions

The investment ecosystem for digital infrastructure is highly fragmented and includes a multiplicity of potential buyers of education technologies, which makes it difficult for EdTech providers – especially smaller ones – to scale up and grow (see Chapter 6). This issue is exacerbated by the strong decentralisation of spending decisions. While the majority of initial funding for school education originates at the central level, in many countries, subnational governments are important actors in school funding (OECD, 2017[35]) (OECD, 2021[36]). On average across OECD countries, decisions related to resources within schools and in particular to budget allocations are relatively decentralised (mostly in the hands of school principals or school boards) (OECD, 2016, p. 334[37]). Some countries provide a high degree of resource autonomy to schools, enabling principals to allocate resources freely across areas of spending (e.g. **Denmark**), whereas other countries (e.g. the **Czech Republic** and **Estonia**) display a more intermediate level of budgetary autonomy.

Yet, strategic investment decisions do not only require budgetary autonomy, but also technological expertise. Acquiring digital infrastructure entails budgeting for IT expertise not only for maintenance and support, but also for designing, installing, and commissioning goods and services. Every institution selecting digital technology is faced with the option of either building in-house IT expertise or outsourcing it. In small scale operations, such as those of schools and smaller HEIs, equipping institutions with (for instance) a highly skilled audio-visual department drives up the total cost of ownership and yields lower return on investment. Because outsourcing involves transaction costs and risks and provides less room for personalisation, larger institutions tend to invest in building their own IT expertise in-house.

Procurement strategies help institutions find a balance that works according to their needs and capacity. The extent to which institutions are able to make procurement decisions depends on the structure of grants and budgets. Lump sum grants may allow institutions to use the resources to buy components and individual pieces of equipment directly from a supplier ("box shifting") as well as IT expertise as part of the procurement ("service relationships"). Earmarked grants may restrict the ability of institutions to use dedicated resources for equipment on service relationships, forcing them to either fund those costs through other sources or undertake procurement decisions without the necessary IT expertise. Many institutions also engage in collective procurement processes, through national level agreements or through institution networks.

Finally, digital infrastructure has traditionally been considered to be capital expenditure, but some digital services may actually require a recurrent funding stream in light of their rapid change and replacement cycles. Cloud services and software subscriptions are examples of areas where one-off investments (e.g. in servers or software licences) are being replaced by recurrent expenditure. This shift in spending from capital to operating budgets can contribute to further fragmentation of the digital education investment process, as decisions for smaller current expenditures may be made at lower levels of an organisation – and less strategically than larger capital purchases, leading potentially to inconsistency or duplication of investments.

Promising approaches for funding and procurement of digital education technologies

Adapt funding and revenue models to digital education

Improve the identification of costs and benefits associated with developing and delivering digital education

The development and introduction of new forms of digitally enhanced learning is costly. As noted above, there have been few systematic attempts to quantify these costs at the level of school education and public higher education systems. Research into the costs of operating online and hybrid higher education programmes is scarce and the available evidence has gained limited traction in most policy making communities. Nevertheless, there is a strong case for further national level analysis of costs and efficiency gains related to digitalisation in education systems and for sharing the results of such analyses internationally.

In higher education, given the pervasive nature of digital technologies and the distribution of capital and staff costs across higher education institutions, it is unlikely that current institutional cost-accounting and reporting systems will allow for the collection of sufficiently fine-grained data on investment and development costs, even in systems where sophisticated cost-accounting models exist (OECD, 2022[38]). Evidence is more likely to be based on institutional level case studies. The large number of targeted funding programmes focused on digitalisation currently underway provides an opportunity to analyse costs alongside programmes' effectiveness. More broadly, there is a case for further consolidating evidence on the costs of different approaches to digital learning and the dissemination of this information through international peer-learning.

Design core and targeted funding to education institutions with digital education in mind

As digital technologies increasingly permeate education systems, revising funding mechanisms may be necessary to achieve a more equitable distribution of funding for digital education. For example, including criteria to systematically allocate more funding for digital education to certain categories of education institutions or students may help to improve equity in access. In this context, the underlying data used as a basis for funding allocations are crucial. The availability and quality of data as well as the design and complexity of indicators are important determinants of the accuracy and efficiency of funding allocation systems (OECD, 2020[39]; OECD, 2017[28]). The extent to which education systems are able to measure digital capacity, the diffusion of digital technologies and the impact of digitalisation on education outputs and outcomes will determine the sophistication of information systems on digital education and in turn, the information available to make efficient adaptations to funding allocation models.

In higher education, once hybrid and online programmes have been developed and, where necessary externally accredited, there are few specific barriers to allocating public funding to HEIs for their delivery under established models. As most formula and voucher-like funding models use cost factors differentiated by study field (e.g. lower for humanities, higher for laboratory-based subjects), the question of which cost factors to use for online programmes will arise. In most cases, available technology does not allow programmes with practical elements to be delivered in fully online modes. Where fully online delivery is feasible, the evidence on operating costs and dominance of staff costs in overall operational costs suggest that online degree programmes should typically be funded with similar cost factors as on-campus programmes. **Scotland** provides an example of a flexible model (Scottish Funding Council, 2021[40]).

When it comes to development, piloting and testing new technologies and approaches to digital learning, an approach of competitive targeted funding can be a valid way to ensure efficient use of resources:

- In **Australia** the Digital Literacy School Grants is a competitive grant program that supports Australian schools in enhancing digital literacy among students and teachers. The program funds innovative projects that promote the development of essential digital skills. Successful projects in a recent funding round included a school-based Technology Design Centre for peer-led teacher training, supports for implementing the Australian Digital Technologies curriculum, and the purchase of a humanoid robot to provide additional learning support for students with special education needs (Department of Education Australian Government, 2021[41]).
- Similarly, a recent adaptation to the funding model for further education and training institutions In **Ireland** introduces a new discretionary "pot" of funds that allows institutions to compete for funding for innovative and transformational projects related to Government priorities, including those related to digital transformation (Department of Further and Higher Education, 2022[42]).

Governments in an increasing number of small and medium-sized jurisdictions use institutional performance agreements to agree and steer the investment priorities in publicly funded higher education institutions. These agreements are mainly regarded as a steering and accountability tool, rather than primarily a funding tool, although a small proportion of institutional funding may be explicitly linked to goals included in the institutional agreements. Digitalisation is one priority area that can usefully be integrated into institutional agreements. In **Austria**, for example, the latest rounds of institutional performance agreements (*Leistungsvereinbarungen*) concluded between institutions and the federal government have included digitalisation as one of a limited number of priorities. The agreements for 2022 to 2024 aim to achieve a significant expansion and development of digital learning (BMBWF, 2022[43]). The broad goals established in the agreements have been complemented by targeted, project-based funding, as seen in multiple other OECD systems (BMBWF, 2021[44]).

Examine whether students enrolled in accredited online higher education programmes should be eligible for student support

In higher education, student financial support systems in OECD countries systematically use student and programme eligibility criteria. Both sets of criteria can be adjusted to widen or restrict the pool of programmes and the population of students that are eligible for financial support when enrolled on these programmes. Many, but not all, student support programmes distinguish between students who relocate to study on campus and those who enrol at institutions near home. Student aid programmes also tend to be more geared towards full-time rather than part-time studies.

Where online and hybrid programmes are considered within national regulations as equivalent to their on-campus counterparts, students may be entitled to have tuition fees covered but may not receive supports for living costs. In the **United Kingdom**, for example, students enrolled in distance education programmes with The Open University, are eligible for tuition fee loans, but not maintenance loans, as Open University students are *de facto* considered as part-time students, irrespective of their actual study intensity (The Open University, 2022[45]).

At the same time, online education programmes and their providers should be carefully assessed to ensure that the programmes being offered are delivering positive benefits for learners. For example, research in the **United States** has shown that many students availing of federal student loans in four-year online programmes offered by for-profit education institutions have poorer completion rates and outcomes and may be more likely to accrue unsustainable debt than students enrolled in other categories of institutions (Howarth and Stifler, 2019[46]).

Build institutions' collective capacity for purchasing digital infrastructure

Support institutional procurement strategies and budget practices

For education institutions, taking responsibility for the acquisition of digital education infrastructure requires them to have sufficient information, capacity and skills to navigate a wealth of EdTech products, services and tools, as well as an understanding of procurement procedures to make effective choices. Without proper information, institutions may end up acquiring technology that requires too much IT support or is too complex to use, leading to digital infrastructure underutilisation. Importantly, enhancing digital infrastructure is not a one-time investment but comes with continuous costs associated with maintaining and upgrading technologies acquired and providing the necessary support for their use (OECD, 2022[47]). Ensuring sufficient access to digital equipment and tools requires anticipating investment needs before shortages and inadequacies arise.

A way in which governments can bridge information gaps and can lower the costs of choosing among alternative technologies and providers is the provision of information platforms on procurement frameworks and EdTech providers. In the **United Kingdom** for instance, the Department for Education school procurement guidance service explains the benefits of using existing frameworks, proposes cost-efficient alternatives based on feedback from schools and supports compliance with the relevant procurement regulations (Gov.uk, 2022[48]). In addition, the government provides schools with digital and technology standards and is developing a tool to help schools to benchmark themselves and to identify technologies they should have in place (Department for Education, 2022[49]). This type of intervention supports the principle on data integration to inform investment strategies and produce evidence for decision-making as outlined in the OECD Recommendation of the Council on the Governance of Infrastructure (OECD, 2020[50]).

Education institutions also benefit from collective capacity building for digital planning and acquisition. Most universities and colleges in the **United Kingdom** belong to a charitable company, the Universities and Colleges Information Systems Association (UCISA) that provides members with case studies, surveys, toolkits, best practice guides and benchmark reports to inform the development of digital capabilities. This includes, for example, a Procurement Group that advises on digital technology acquisition decisions, and a Digital Infrastructure Group that advises on technology and services that sit between networks and end-user applications (UCISA, 2022[51]).

Align procurement strategies to governance arrangements and the degree of institutional budgetary autonomy

As discussed previously, countries give education institutions different degrees of freedom in choosing suppliers for their digital infrastructure needs. In this context, procurement practices and options are also likely to vary, albeit within the common objective to achieve scale economies and efficiency gains wherever possible.

At one extreme of this spectrum is a highly centralised procurement approach, whereby a state agency buys digital systems and equipment on behalf of all the institutions in the national education network. For instance, in **Hungary**, all public HEIs' procurement requests are considered, prioritised and acted on by a national agency (OECD, 2021[52]). A centralised process can reduce the complexity and risks of procurement systems; improve efficiency and ensure systems are interoperable. A centralised strategy may also be suitable when institutions have low internal capacity and resources to dedicate to a procurement strategy. However, for institutions that can build that capacity, centralised services can be perceived as inflexible, slow and unable to tackle requests not prioritised in the national agenda (OECD, 2021[52]).

In more autonomous systems, by contrast, governments allow education institutions to decide on their digital infrastructure investments. There, the use of purchasing consortia or framework agreements for digital infrastructure purchases appears as a cost-effective approach to achieve efficiency gains in procurement management.

- In the **United Kingdom**, public higher education institutions have autonomy to manage their digital infrastructure and can make use of multiple national and regional procurement frameworks including the "open frameworks for educational technology" through the Crown Commercial Service (Crown Commercial Service, 2022[53]). Institutions can also form purchasing consortia for collaborative procurement including among regional consortia as in the case of the UK Universities Purchasing Consortia, a formal entity formed by eight UK regional consortia to support collaborative procurement within Higher and Further Education (UKUPC, 2022[54]).
- The **Flemish Community of Belgium** established a framework agreement with the private telecom sector and software resellers to provide better conditions for educational institutions (van der Vlies, 2020[55]).

Other countries, at the higher education level, have opted for centralising only a limited range of digital services that are less subject to personalisation and have an overarching impact on the security of the system. In **Norway** for instance, the Norwegian Directorate for ICT and Joint Services in Higher Education & Research (UNIT) offers a common digital architecture to centralise, harmonise and standardise services related to security and access (UNIT, 2021[56]), but gives institutions freedom to choose services that can be tailored to their needs such as LMS and Virtual Learning Environments (VLEs) (OECD, 2021[52]). Additionally, in 2017 the National Research and Education Network including 17 Norwegian HEIs managed the procurement of Canvas (a LMS) to simplify the procurement process for individual institutions, effectively leading to convergence in use of LMS across HEIs.

Comparative evidence on the procurement practices for education technology is, however, currently lacking. Collecting such evidence would entail a better understanding of how different practices better support education systems in acquiring education technology. Indeed, if more decentralised procurement practices enable schools or agencies to benefit from flexibility in choosing products and tools aligned with their specific needs, they also entail higher sales costs for companies, more difficulty to navigate a variety of procurement procedures and fewer opportunities to scale as demand remains fragmented.

Support value for money investments and economies of scale in procurement through partnerships and procurement collaboration platforms

Networking and collaborative procurement platforms and associations provide a flexible way to standardise procurement practices and negotiating better prices:

- In **the Netherlands,** the government provided a start-up 5-year subsidy to SIVON, a co-operative association of school boards that supports purchasing of digital education resources, including through the provision of framework agreements with providers leading to lower costs for schools (Nederland Digitaal, 2022[57]). In higher education, SURF (a collaborative organisation) relies on a combination of peer learning and expert advice to guide digital infrastructure choices of over 100 member institutions (SURF, 2022[58]).
- In **Lithuania** and **Croatia**, consortia and NRENs provide centralised hosting services such as Zoom and Moodle on top of providing network connectivity (LieDM, 2022[59]) (CARNET, 2022[60]).
- **Ireland**'s NREN HEAnet brokers hardware, software, support and professional services on behalf of HEIs, effectively streamlining procurement processes and negotiating aggregate deals from which all members can benefit (National Forum for the Enhancement of Teaching and Learning in Higher Education, 2017[4]).
- Several NRENs in Europe support the purchasing of cloud services and GÉANT offers framework contracts for institutions to buy cloud services without running their own tender or call-for-competition (Géant, 2022[61]).[5]

Key Messages

Understanding the costs associated with investments in digital education is a precondition to evaluate their efficiency. Yet, the analysis in this chapter highlights that policy makers in many countries have limited information on the extent of public spending on digital education. Adapting budgeting and accounting practices to better track expenditure related to digital education might be a first step to improve the knowledge base underlying digital investment decisions.

In addition to the amount of spending, the ways in which funding for digital education is raised and allocated is essential to facilitate the successful digitalisation of education institutions. For instance, drawing funding for digital education primarily from revenues raised at sub-central levels might result in investment disparities based on differences in local revenue-raising powers and preferences.

Digital education spending comprises both large one-time investments and recurring costs (e.g. associated with the maintenance of digital equipment). This requires institution-level and system-level budgeting to be forward-looking and to take into account both capital and current expenditure.

Funding allocation mechanisms for digital education also need to strike a balance between providing reliable financial flows to education institutions to cover recurring costs and maintaining the flexibility to enable targeted funding for specific investments. This is particularly relevant given the fast-changing technological environment, which can lead to unexpected funding needs.

Finally, fragmented markets for digital technologies might inhibit education institutions' ability to make effective and cost-efficient procurement decisions. As discussed in Chapter 3, individual education institutions might lack the capacity to select adequate education technologies and their limited bargaining power can prevent them getting the best value for money. This chapter therefore presents a range of measures, such as purchasing consortia or standardised framework agreements, to support education institutions in the procurement process.

References

BMBWF (2022), *Rekordbudget an den Universitäten: Leistungsvereinbarungen 2022-24*, Bundesministerium für Bildung, Wissenschaft und Forschung, https://www.bmbwf.gv.at/Ministerium/Presse/20220104.html (accessed on 29 June 2022). [43]

BMBWF (2021), *Digitalisierung und Hochschulen (Digitalisation and higher education institutions)*, Bundesministerium für Bildung, Wissenschaft und Forschung, https://www.bmbwf.gv.at/Themen/HS-Uni/Hochschulgovernance/Leitthemen/Digitalisierung.html (accessed on 29 June 2022). [44]

Bowen, W. et al. (2013), *Online Learning in Higher Education*, https://www.educationnext.org/online-learning-in-higher-education/ (accessed on 23 August 2022). [19]

Bulman, G. and R. Fairlie (2016), "Technology and Education: Computers, Software, and the Internet", in *Handbook of the Economics of Education*, https://doi.org/10.1016/B978-0-444-63459-7.00005-1. [16]

CARNET (2022), *CARNET - Linking knowledge*, https://www.carnet.hr/en/ (accessed on March 2022). [60]

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. [18]

Council of the Great City Schools (2020), *Managing for Results in America's Great City Schools*, https://www.cgcs.org/cms/lib/DC00001581/Centricity/domain/35/publication%20docs/Managing%20for%20Results%20in%20Americas%20Great%20City%20Schools%202020.pdf (accessed on 20 May 2022). [9]

Crown Commercial Service (2022), *Education Technology*, https://www.crowncommercial.gov.uk/agreements/RM6103 (accessed on March 2022). [53]

Department for Education (2022), *Meeting digital and technology standards in schools and colleges*, https://www.gov.uk/guidance/meeting-digital-and-technology-standards-in-schools-and-colleges (accessed on 3 April 2023). [49]

Department of Education Australian Government (2021), *Digital Literacy School Grants Round 1 - successful projects*, https://www.education.gov.au/australian-curriculum/resources/digital-literacy-school-grants-round-1-successful-projects (accessed on 17 April 2023). [41]

Department of Further and Higher Education, R. (2022), *Significant shift in how further education and training sector is funded announced by Minister Harris*, https://www.gov.ie/en/press-release/8510f-significant-shift-in-how-further-education-and-training-sector-is-funded-announced-by-minister-harris/ (accessed on 17 April 2023). [42]

Digitaliseringsimpuls Onderwijs (2022), *Digitaliseringsimpuls Onderwijs (Digitalisation impulse education)*, Digitaliseringsimpuls Onderwijs, https://www.digitaliseringsimpuls.nl/ (accessed on 24 June 2022). [33]

Educause (2022), *IT Spending and Staffing*, https://www.educause.edu/research-and-publications/research/analytics-services/it-spending-and-staffing-interactive-almanac (accessed on March 2022). [8]

Educause (2022), *IT Spending and Staffing - CDS Interactive Almanac*, Educause, https://www.educause.edu/research-and-publications/research/analytics-services/it-spending-and-staffing-interactive-almanac (accessed on 24 June 2022). [5]

EFI (2019), *Gutachten zu Forschung, Innovation und technologischer Leistungsfähigkeit Deutschlands 2019 (Report on Research, Innovation and technological capacity in Germany 2019)*, Expertenkommission Forschung und Innovation (EFI), https://www.e-fi.de/publikationen/gutachten (accessed on 24 June 2022). [12]

Escueta, M. et al. (2017), "Education Technology: An Evidence-Based Review", http://www.nber.org/papers/w23744. [15]

EUA (2021), *Digitally enhanced learning and teaching in European higher education institutions - Survey report*, DIGI-HE project, https://eua.eu/resources/publications/954:digitally-enhanced-learning-and-teaching-in-european-higher-education-institutions.html (accessed on 24 June 2022). [11]

European Commission/EACEA/Eurydice (2019), *Digital Education at School in Europe*, Eurydice Report. Luxembourg: Publications Office of the European Union, https://eacea.ec.europa.eu/national-policies/eurydice/content/digital-education-school-europe_en (accessed on 4 August 2020). [3]

Géant (2022), *Support for Institutions*, https://clouds.geant.org/support-for-institutions/ (accessed on March 2022). [61]

Gov.uk (2022), *Guidance: Find a DfE-approved framework for your school*, https://www.gov.uk/guidance/find-a-dfe-approved-framework-for-your-school (accessed on March 2022). [48]

Government of France (2021), *Numérique éducatif : le Premier ministre dresse le bilan des enseignements de la crise et présente des mesures de soutien à l'innovation*, Ministry of Higher Education and Research, https://www.enseignementsup-recherche.gouv.fr/fr/numerique-educatif-le-premier-ministre-dresse-le-bilan-des-enseignements-de-la-crise-et-presente-des-50939 (accessed on 24 June 2022). [34]

Government of the Netherlands (2021), *Ambtelijke verkenning met beleidsopties voor groei (Exploratory analysis on policy options for growth)*, https://www.rijksoverheid.nl/documenten/publicaties/2021/03/19/ambtelijke-verkenning-met-beleidsopties-voor-groei (accessed on 24 June 2022). [23]

Hemelt, S. et al. (2018), *Why is Math Cheaper than English? Understanding Cost Differences in Higher Education*, http://www.iza.org (accessed on 23 November 2020). [20]

HolonIQ (2021), *Global Education Technology in 10 Charts*, http://www.holoniq.com (accessed on 7 April 2022). [7]

HolonIQ (2020), *Global EdTech market to reach $404B by 2025 - 16.3% CAGR*, https://www.holoniq.com/notes/global-education-technology-market-to-reach-404b-by-2025/ (accessed on 10 August 2020). [6]

Howarth, R. and L. Stifler (2019), "The Failings of Online For-profit Colleges: Findings from Student Borrower Focus Groups", https://www.brookings.edu (accessed on 17 April 2023). [46]

HRK (2021), *Forderungen an Bund und Länder zur Weiterentwicklung der digitalen Lehrinfrastrukturen - (Demands to the federal and state governments for the development of digital teaching infrastructures)*, Hochschulrektorenkonferenz (German Rectors' Conference) - HRK, https://www.hrk.de/positionen/beschluss/detail/forderungen-an-bund-und-laender-zur-weiterentwicklung-der-digitalen-lehrinfrastrukturen/ (accessed on 24 June 2022). [13]

Hummel-Rossi, B. and J. Ashdown (2002), "The state of cost-benefit and cost-effectiveness analyses in education", *Review of Educational Research*, Vol. 72/1, pp. 1-30, https://doi.org/10.3102/00346543072001001. [26]

LieDM (2022), *LieDM consortium*, https://liedm.lt/ (accessed on March 2022). [59]

Ma, Y. et al. (2020), "Isolating the "Tech" from EdTech: Experimental Evidence on Computer Assisted Learning in China. NBER Working Paper No. 26953.", *National Bureau of Economic Research*, No. 26953, National Bureau of Economic Research, https://doi.org/10.3386/w26953. [14]

National Forum for the Enhancement of Teaching and Learning in Higher Education (2017), *Ireland's Higher Education Technical Infrastructure: A review of current context, with implications for teaching*, https://hub.teachingandlearning.ie/wp-content/uploads/2021/06/NF-2017-Irelands-Higher-Education-Technical-Infrastructure-A-Review-of-Current-Context-with-Implications-for-Teaching-and-Learning-Enhancement.pdf. [4]

Nederland Digitaal (2022), *Digitisation agenda. Primary and secondary education*, https://www.nederlanddigitaal.nl/initiatieven/digitaliseringsagenda-primair-en-voortgezet-onderwijs (accessed on March 2022). [57]

NESTA (2021), *EdTech usage during the pandemic: A story in four graphs*, https://www.nesta.org.uk/project-updates/edtech-usage-story-four-graphs/ (accessed on 11 April 2022). [17]

OECD (2022), *Access to computers from home*, https://data.oecd.org/ict/access-to-computers-from-home.htm (accessed on March 2022). [47]

OECD (2022), "Resourcing higher education in Ireland : Funding higher education institutions", *OECD Education Policy Perspectives*, No. 51, OECD Publishing, Paris, https://doi.org/10.1787/67dd76e0-en. (accessed on 29 June 2022). [38]

OECD (2022), *Value for Money in School Education: Smart Investments, Quality Outcomes, Equal Opportunities*, OECD Publishing, Paris, https://doi.org/10.1787/f6de8710-en. [25]

OECD (2021), *Delivering Quality Education and Health Care to All: Preparing Regions for Demographic Change*, OECD Rural Studies, OECD Publishing, Paris, https://doi.org/10.1787/83025c02-en. [36]

OECD (2021), *Education at a Glance 2021: OECD Indicators*, OECD Publishing, Paris, https://doi.org/10.1787/b35a14e5-en. [1]

OECD (2021), *Supporting the Digital Transformation of Higher Education in Hungary*, Higher Education, OECD Publishing, Paris, https://doi.org/10.1787/d30ab43f-en. [52]

OECD (2021), "Towards equity in school funding policies", *OECD Education Policy Perspectives*, No. 41, OECD Publishing, Paris, https://www.oecd-ilibrary.org/docserver/6a3d127a-en.pdf?expires=1642414595&id=id&accname=ocid84004878&checksum=1D53BFCFBDA3E73EFAE8B747DF0587C1 (accessed on 17 January 2022). [29]

OECD (2020), *Recommendation of the Council on the Governance of Infrastructure*, https://legalinstruments.oecd.org/en/instruments/OECD-LEGAL-0460 (accessed on March 2022). [50]

OECD (2020), *Resourcing Higher Education: Challenges, Choices and Consequences*, Higher Education, OECD Publishing, Paris, https://doi.org/10.1787/735e1f44-en. [39]

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. [10]

OECD (2018), *Responsive School Systems: Connecting Facilities, Sectors and Programmes for Student Success*, OECD Reviews of School Resources, OECD Publishing, Paris, https://doi.org/10.1787/9789264306707-en. [30]

OECD (2017), *OECD Digital Economy Outlook 2017*, OECD Publishing, Paris, https://doi.org/10.1787/9789264276284-en. [2]

OECD (2017), *The Funding of School Education: Connecting Resources and Learning*, OECD Publishing, Paris, https://www.oecd-ilibrary.org/docserver/9789264276147-en.pdf?expires=1649415581&id=id&accname=guest&checksum=A3F04B3D73C26CD2E31E745E654398DE (accessed on 8 April 2022). [28]

OECD (2017), *The Funding of School Education: Connecting Resources and Learning*, OECD Publishing, Paris. [35]

OECD (2016), *PISA 2015 Results (Volume II): Policies and Practices for Successful Schools*, PISA, OECD Publishing, Paris, https://www.oecd-ilibrary.org/docserver/9789264267510-en.pdf?expires=1649421990&id=id&accname=ocid84004878&checksum=317A6F81EF2C71F92F72BDC1BAB62EAF (accessed on 8 April 2022). [37]

OECD (2013), *Synergies for Better Learning - an international perspective on evaluation and assessment*, https://doi.org/10.1787/9789264190658-en (accessed on 26 September 2022). [27]

Scottish Funding Council (2021), *University Final Funding Allocations AY 2021-22*, Scottish Funding Council, https://www.sfc.ac.uk/publications-statistics/announcements/2021/SFCAN202021.aspx (accessed on 29 June 2022). [40]

Stiftung Hochschullehre (2022), *Stiftung Innovation in der Hochschullehre (Foundation for innovation in higher education teaching)*, Stiftung Hochschullehre, https://stiftung-hochschullehre.de/ueber-uns/ (accessed on 24 June 2022). [32]

SURF (2022), *SURF is the collaborative organisation for IT in Dutch education and research*, https://www.surf.nl/en (accessed on March 2022). [58]

SURF (2016), *Verkenning: opschaling van open en online onderwijs (Exploratory report: scaling up open and online education)*, https://www.surf.nl/verkenning-opschaling-van-open-en-online-onderwijs (accessed on 29 June 2022). [31]

The Open University (2022), *Fees and funding*, The Open University, https://www.open.ac.uk/courses/fees-and-funding (accessed on 29 June 2022). [45]

UCISA (2022), *Education & Support Groups for Digital Practitioners - UCISA*, https://www.ucisa.ac.uk/Groups (accessed on 19 May 2022). [51]

UKUPC (2022), *About us*, https://www.ukupc.ac.uk/ (accessed on March 2022). [54]

UNIT (2021), *Mandate for the Digitization Board from 2021*, https://www.unit.no/mandat-digitaliseringsstyret-fra-2021 (accessed on March 2022). [56]

van Baalen, P. et al. (2021), *Met digitalisering van het hoger onderwijs rekent het Rijk zich onterecht rijk (When it comes to digitalisation in higher education the government has over-estimated what money can buy)*, ScienceGuide, https://www.scienceguide.nl/2021/04/met-digitalisering-van-het-hoger-onderwijs-rekent-het-rijk-zich-onterecht-rijk/ (accessed on 24 June 2022). [24]

van der Vlies, R. (2020), “Digital strategies in education across OECD countries: Exploring education policies on digital technologies”*, OECD Education Working Papers*, No. 226, OECD Publishing, Paris, https://doi.org/10.1787/33dd4c26-en. [55]

Wolff, E., W. Baumol and A. Saini (2014), “A comparative analysis of education costs and outcomes: The United States vs. other OECD countries”, *Economics of Education Review*, Vol. 39, pp. 1-21, https://doi.org/10.1016/j.econedurev.2013.12.002. [21]

Xu, D. and Y. Xu (2019), *The Promises and Limits of Online Higher Education - Understanding how distance education affects access, cost and quality*, American Enterprise Institute (AEI), Washington, D.C., https://www.aei.org/wp-content/uploads/2019/03/The-Promises-and-Limits-of-Online-Higher-Education.pdf (accessed on 8 April 2020). [22]

Notes

[1] Current expenditure is defined as "spending on staff compensation and on "Other current expenditure", i.e. on goods and services consumed within the current year, which require recurrent production in order to sustain educational services (expenditure on support services, ancillary services like preparation of meals for students, rental of school buildings and other facilities, etc.). These services are obtained from outside providers, unlike the services provided by education authorities or by educational institutions using their own personnel" (OECD, 2021[1]).

[2] Capital expenditure is defined as "spending on assets that last longer than one year, including construction, renovation or major repair of buildings, and new or replacement equipment. Neither capital nor current expenditure includes debt servicing" (OECD, 2021[1]).

[3] For the 22 EU countries with available data, on average 78% of current expenditure was dedicated to staff (63% to teachers and 15% to other staff, including support, professional and research staff) and 22% to other current expenditure.

[4] Funding for current expenditure can be allocated funds through a range of mechanisms (lump sum transfers, earmarked funding, block grants, etc.) and funding formulas are often the major basis for determining the amount of funding to be distributed for current expenditure. For capital expenditure, the main allocation mechanisms include infrastructure investment programmes, ad hoc administration of grants and competitive processes. The assessment of needs is often the major basis for the allocation of funding for capital expenditure.

[5] The framework contracts comply with EU data protection law and were established using the EC 2014/24/EU procurement directive, which allows you to use the services directly

6 Accessible, innovative and high-quality infrastructure for digital education

The chapter covers recent developments related to the provision of accessible, innovative and high-quality digital infrastructure across education systems. It finds that a range of challenges remain to ensure equity in access to digital infrastructure, and that current levels of investment in innovative education technologies are likely to be insufficient. The chapter recommends that governments should further invest in digital infrastructure that promotes equitable learning opportunities and seek to boost investment and innovation in education technologies through multi-dimensional and co-ordinated innovation, entrepreneurship or funding policies.

Introduction

The success of digital education strategies hinges upon wide and equitable access to digital infrastructure, including connectivity, hardware, software, tools and services. All students, teachers and schools should have access to at least a minimum extent of high-quality technologies that are a prerequisite for digitally enabled education systems. This chapter examines the availability and adequacy of digital infrastructure for education, with a focus on accessibility, equity of distribution (e.g. across education institutions and students) and quality (e.g. in terms of Internet speed, broadband width or computing power). Whilst much of the available data on digital education infrastructure stems from prior to the COVID-19 pandemic, education systems have made significant advances in their digital infrastructure in recent years. This chapter considers how policies can further advance the availability and accessibility of this digital infrastructure and foster innovation to reap the full benefits of cutting edge digital tools for education.

Reliable connectivity for all is the foundation of digital education. Ensuring quality and equity in schools' Internet access and learners' home Internet access requires overarching policies to promote and facilitate adequate broadband deployment, and more targeted efforts by education ministries. Such efforts can include providing funding to education institutions for affordable broadband and extending Internet reach to all education institutions and students, including learners or schools in remote locations.

Beyond connectivity, there is also a need to ensure widespread access to quality digital equipment (hardware and software), tools and services. Successfully targeting equipment gaps requires a comprehensive policy approach with a strong capacity building component targeted at education institutions, teachers, students and parents. Capacity building might entail building partnerships with a range of stakeholders (e.g. private sector, statistics institutes, and local communities) and mobilising knowledge networks.

Policy makers should not only ensure the access to quality digital infrastructure today but anticipate how digital tools can support teaching and learning in the future. In this respect, governments play a key role in creating the conditions that can promote innovation in digital education technologies, including through general policies to stimulate entrepreneurship, and stimulating both public and private investment in the development of education technologies. Providing support to access finance and business investment, setting up innovation funds and providing grants for digital education technologies' development and innovation as well as supporting education technology incubators or accelerators are among the policy levers that governments may consider to sustain a dynamic education technology sector. Governments may also aim for monitoring developments in the education technology industry to ensure sufficient investments and inform innovation-related policies for digital education technologies.

Building the necessary infrastructure for digital education thus comes with a range of challenges which this chapter aims to address by analysing existing evidence and presenting promising policy examples from OECD and EU countries. Some of the key questions on this issue that policy makers need to consider include:

- How can education systems support access to fast and reliable Internet connection for all schools, teachers and students?
- How can education systems provide access to quality digital education equipment (hardware and software) in schools and at home for all learners while anticipating further investment and maintenance needs?
- How can education systems stimulate private investment in and support innovation of hardware, software and services?

Recent developments and current challenges

Despite progress in coverage and take-up, fast and reliable Internet connection is not yet accessible to all communities and learners

Substantial disparities persist in access to and quality of Internet connection in learners' homes

Network connectivity in education institutions and at home, whether through mobile/fixed networks or communication satellites, is essential to digital learning activities, student-teacher digital interaction and the interoperability of systems. While speed and capacity requirements vary across tools, stable high-speed broadband connectivity with low latency (i.e. the time it takes for data to travel between sender and receiver) is necessary for both real-time (synchronous) online interactions asynchronous (i.e. self-paced) virtual learning. Indeed, with the exponential rise of data and audio-visual content, only a stable, high-speed connection is a useful one. Adequate wireless broadband connectivity is also needed to ensure full connectivity in large physical learning spaces such as university campuses.

The pandemic accentuated the need for access to institutional networks from home or other places of study (off-site), increasing the role of public wired networks (including fibre) and mobile data access (4G, 5G, satellite) of adequate speed and reliability for online access to learning. The extent to which internet connectivity can be considered adequate and reliable for learning needs will vary depending on the connection speed, the type of learning activity, the extent to which there is contention for the available bandwidth from other devices or household members and (in the case of mobile data) caps or limitations on data imposed by mobile data providers. For example, online meeting software such as Zoom uses up to 900 MB of data per hour in group calls – and more than 2GB of data per hour in high-definition mode (Holslin, 2021[1]). High-speed network connectivity is considered to not only be necessary for performing digital learning activities; it can also support better learning outcomes (Sanchis-Guarner, Montalbán and Weinhardt, 2021[2]) the transition to higher education (Dettling, Goodman and Smith, 2018[3]) and online learning uptake in higher education (Skinner, 2019[4]).

According to the 2022 European Union's Digital Economy and Society Index (DESI): 78% of households had broadband; 90% had fast broadband (Next Generation Access or NGA) (but only 41% had access to fast – at least 100 Mbps – fixed broadband); 87% had mobile broadband; 66% had 5G coverage; while 70% had Fixed Very High Capacity Network (VHCN) coverage (European Commission, 2021[5]). The DESI index (which combines fixed broadband take-up and coverage with mobile broadband indicators and prices) ranges from over 60 (out of a maximum of 100) in Denmark, the Netherlands and Spain, to under 40 in Bulgaria and Greece.

In terms of network technology trends, 2021 data for 38 OECD member countries show different technology mixes coupled with a strong move towards fibre, which now makes up 32% of fixed broadband subscriptions (20 percentage points more than a decade ago) (OECD, 2022[6]). While mobile broadband expanded considerably as a result of the pandemic, growth is now more stable compared to a decade ago, due to a greater take-up of fixed networks, in part because of their greater reliability for study, work and leisure. The deployment of 5G networks in EU countries advanced rapidly during the pandemic: 5G commercial services are now available in all 27 EU member states, with 62% of Europeans reached by a 5G network in 2021 (compared to 30% in 2020) (5G Observatory, 2022[7]). Connectivity at home was critical in enabling students to remain connected to their teachers and peers and continue learning online during the COVID-19 pandemic. On average across OECD countries, 96% of 15-year-old students reported having access to an Internet connection at home in 2018 (OECD, 2019[8]). In EU countries, less than 1% of surveyed students in PISA (2018) did not have an internet-connected mobile phone in their household. Inequities in access to Internet at home remain, however, in a number of OECD countries.

Fewer students from socio-economically disadvantaged schools[1] benefitted from an Internet connection at home than their peers in socio-economically advantaged schools in Bulgaria (6% gap in the share of students with an Internet connection at home between students from socio-economically advantaged and disadvantaged schools), Greece (9% gap), Malta (5% gap), the Slovak Republic (6% gap) and Romania (9% gap). Similar gaps were observed between students in rural and urban areas in Bulgaria (8%), Greece (10%), Hungary (9% gap) and Romania (11%).

For higher education, there are no comprehensive cross-country statistics on differences experienced by learners in their household connectivity. However, available national evidence also points to gaps in accessibility. For example, evidence for Ireland during the pandemic showed one in six students came from areas with poor broadband coverage, with those in the areas with poorest broadband coverage being more likely to be socio-economically disadvantaged (Cullinan et al., 2021[9]). A survey of 511 entrants to higher education during the pandemic period in the UK also indicated that while, on average, only 7% reported having insufficient access to the Internet, this percentage rose to 12% among those from lower socio-economic households (Montacute, Rebecca; Holt-White, Erica, 2020[10]).

High-speed Internet connection is not yet the norm in all communities and schools

Across all OECD countries and economies, quality Internet access in schools is positively correlated with student performance and equity in reading[2], even after accounting for GDP per capita (OECD, 2020[11]). More generally, countries and economies with fewer material resource shortages, in particular education materials (e.g. digital equipment, textbooks)[3] tend to display better performance in PISA assessments. In addition, countries and economies that have smaller differences in material resources between advantaged and disadvantaged schools also display higher reading performance levels. Education institutions can help narrow connectivity access gaps in countries where socio-economic background or geography impact Internet access at home. Access to the Internet in schools was almost universal in 2018 in OECD and EU member countries and has likely increased even further since the pandemic. More than 96% of school computers available to students across OECD countries were connected to the Internet, according to school principals' reports in PISA 2018 (OECD, 2019[8]). Socio-economically advantaged schools tend to have larger shares of computers connected to the Internet in Colombia (43% gap), Costa Rica (17% gap), Iceland (6% gap), Lithuania (2% gap), Luxembourg (5% gap), Mexico (42% gap) and Türkiye (16% gap). In contrast, the rest of OECD countries displayed no statistically significant gap in students' access to internet-connected school computers for education purposes by school socio-economic profile.

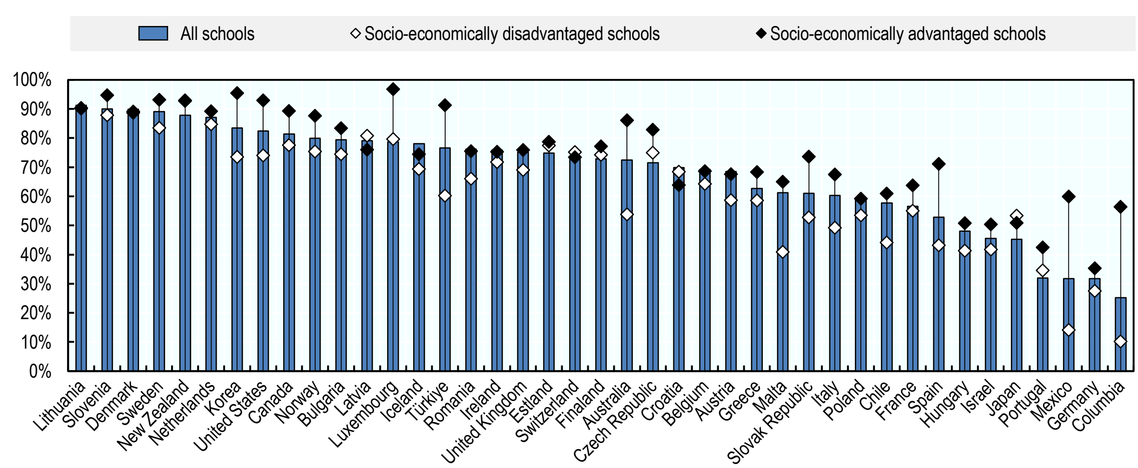
However, the mere availability of Internet connection is not sufficient to support student learning, unless adequate Internet speed is also guaranteed. Many students in OECD countries lack access to high-speed Internet in schools: in 2018, nearly one-third of 15-year-olds in OECD countries were in schools where the principal reported that the school's Internet bandwidth or speed was insufficient (Figure 6.1). Analyses based on PISA (2018) show that principals in schools with a high share of socio-economically disadvantaged students are also less likely to report that their school benefits from high-quality Internet connection. In 2018, in OECD and EU countries, gaps in access between socio-economically advantaged and disadvantaged schools were as high as 32% in Australia, 46% in Colombia and Mexico, 18% in Italy, 24% in Malta, 21% in the Slovak Republic, 28% in Spain and 31% in Türkiye. Data from the 2022 PISA round will show whether the broad investments in schools' digital infrastructure since the pandemic have helped to narrow these gaps.

Among European countries, according to the most recent available data prior to the pandemic, the share of schools benefitting from fibre optic cable connection was on the rise, but only around 32% of students in primary schools, 40% in lower secondary schools and 51% in upper secondary schools had Internet access through fibre optic in 2017-2018 (European Commission, 2019[12]). The remainder of schools were mostly connected through ADSL, followed by cable connections, and only a minority of schools had satellite connections. In addition, cross-country inequalities in students' access to fibre optic in schools remained particularly large before the pandemic (European Commission, 2019[12]). Evidence from PISA (2018) on principals' perceptions on the adequacy of Internet connection speed in their schools shows that while high-speed Internet connection was available to 9 in 10 students in Lithuania, only 1 in 3 students in Germany and Portugal were in schools whose principals reported sufficient Internet speed in 2018 (Figure 6.1). While more updated data is not available, it is likely that the share of education institutions with fibre optic connections has substantially expanded in the ensuing years, given that the share of European households with fibre optic cables tripled between 2017 and2022 (Observatorio Nacional 5G, 2022[13]).

In addition, inequalities in access to a fast Internet connection persist also across geographic areas within countries. In 2018, students attending schools in rural areas were, on average, less likely to benefit from high-speed Internet and to connect to the Internet through fibre optic (European Commission, 2019[12]). Some countries also display particularly large gaps in access to quality Internet connection between students in rural and urban schools. Gaps in access between students in rural schools and those in urban schools were as high as 28% in Costa Rica, 30% in Mexico, 44% in Romania and 21% in Slovenia (OECD, 2019[8]).

Figure 6.1. Sufficient Internet bandwidth or speed in schools, by school type

Percentage of students whose principals agree or strongly agree that the school's Internet bandwidth or speed is sufficient to enhance teaching and learning with digital devices, by school type



Source: Adapted from OECD (2018[14]), PISA Database 2018, https://www.oecd.org/pisa/data/2018database/ (accessed 20 May 2022)

StatLink https://stat.link/sj7n21

Challenges remain to ensuring equity and quality in learners' access to digital education equipment

> *While access to computers in schools is almost universal in OECD countries, most schools are not highly equipped with digital tools*

Access to computers for education purposes was extensive in OECD countries. On average across schools in OECD countries in 2018, there were 0.8 computers available for education purposes for every

15-year-old student, and the computer-student ratio had largely increased since 2009 (OECD, 2020[11]). However, challenges remained with respect to making these computers widely accessible to students in all learning situations. On average across OECD countries, only 40% of computers were portable (e.g. laptop, tablet), although this share is increasing. Northern European countries (Denmark, Norway and Sweden) feature the highest share of portable computers, reaching up to 98.4% of students in Sweden, followed by the United States (79%) and Australia (74%) (OECD, 2020[11]). Similarly, only a third of lower secondary students in the EU had access to desktop computers within the classroom. Instead, most students tended to access school desktop computers in school laboratories, which may limit the potential of digital technology use in regular teaching and learning activities beyond IT classes if school desktop computers are the only devices students have access to at school (European Commission, 2019[12]).

Previous European surveys have developed the concept of "digitally equipped and connected schools" with respect to schools' levels of connectedness and access to digital equipment[4] and highlighted broad cross-national variation in the share of these schools. In European countries with available data, students from Nordic countries and at higher levels of education are more likely to attend schools that are well-equipped in terms of fully operational equipment (e.g. computers, interactive whiteboards), connected to high-speed Internet and with access to a range of digital content related sources (e.g. virtual learning environment, a platform for online school-home communication) (European Commission, 2019[12]). In addition, on average across EU countries, the share of digitally equipped and connected schools is higher at higher school levels.

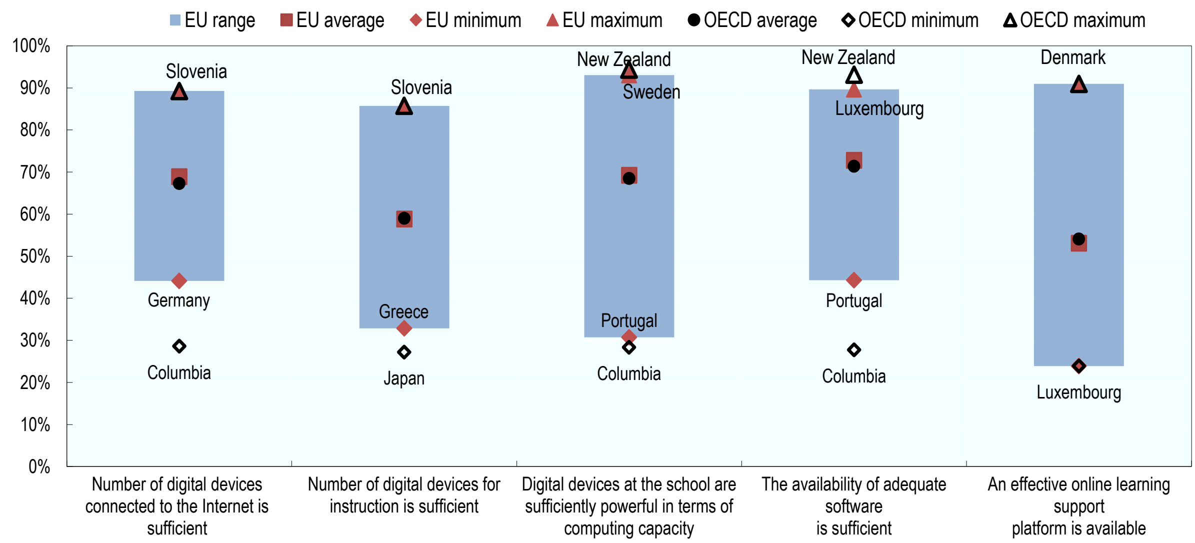
The quality of digital equipment available in education institutions is highly variable between and within OECD countries

The mere availability of digital equipment is insufficient to support student learning if computers are old or education software inadequate. Data from PISA (2018) provide evidence on the perceived sufficiency and adequacy of specific digital technologies available for learning and teaching in schools (Figure 6.2). While students' overall access to school desktop computers was widespread across OECD countries, school principals did not perceive that the number of digital devices for instruction was sufficient (OECD, 2019[8]). This raises questions about the adequate distribution of computers within the school premises and availability of computers for regular instruction, although countries might have advanced on these issues since the COVID-19 pandemic. Similar questions emerge also with respect to the quality of digital equipment available in schools. In European countries, only around 60% of lower secondary school students in Europe were in schools where more than 90% of the equipment (desktop computers, interactive whiteboards, laptops/notebooks and mobile devices) was fully operational, with large cross-country differences (European Commission, 2019[12]).

Within-country inequalities in access to equipment of sufficient quality also exist. On average across countries, perceptions of shortages or inadequate digital technologies are more recurrent among students from disadvantaged schools. For instance, the gap between the percentage of students from disadvantaged schools and those from advantaged schools accessing powerful digital devices at school is 29% in Colombia, 17% in Hungary, 36% in Mexico and 21% in Spain (OECD, 2019[8]). TALIS data depict similar inequities based on the views of school principals: the shortage or inadequacy of digital technology (e.g. software, computers, laptops and smart boards) is more likely to hamper the quality of instruction in schools with a large concentration of socio-economically disadvantaged students (OECD, 2022[15]).

Figure 6.2. Adequacy of digital technologies in schools

Percentage of students in schools whose principal agreed or strongly agreed with the different statements about the school's capacity to enhance learning and teaching using digital devices



Source: Adapted from OECD (2018[14]), PISA Database 2018, https://www.oecd.org/pisa/data/2018database/ (accessed 22 May 2022)

StatLink https://stat.link/f90rxj

In HEIs students generally appear to enjoy wider access to campus-based digital infrastructure, compared to schools. HEIs have access to NREN-provided high-speed Internet connectivity and have achieved near-universal adoption of VLEs. In the United Kingdom, for example, all but 3% of HEIs reported VLE adoption in 2022 (Mosley, 2022[16]). The offer of open-source VLEs, such as Moodle, also provides wide access to a basic VLE for HEIs.

Divides in access to digital equipment at home persist in OECD countries

Despite recent advances in connecting individuals and students, divides in access to digital equipment at home persist in OECD countries and were a major challenge during the COVID-19 pandemic. As the pandemic forced students to study from home, gaps in access to digital technologies from home became important obstacles to learning activities and left some students behind. For example, in an April 2020 non-probability survey conducted by the European Students Union, among 17 000 higher education student respondents, about 10% reported facing some difficulties with access to a home computer, and 60% reported facing some difficulties securing a high-quality home Internet connection (OECD, 2021[17]). In addition, a survey of 114 European HEIs showed that almost half of them had to take action to address digital divides among their students in the first three months of the pandemic (OECD, 2021[17]).

When school computers are not portable, the availability of digital equipment at home becomes crucial to enable students' access to learning opportunities. In this respect, prior to the pandemic, around 93% of 15-year-old students in OECD countries reported having access at home to a computer that they could use for schoolwork (PISA, 2018). On average across the OECD, students from socio-economically disadvantaged schools were less likely to have access to a computer for schoolwork at home (14% gap)

(PISA, 2018). In Mexico, around 24% of 15-year-old students from disadvantaged schools had access to a computer for schoolwork at home, in contrast to 87% of students in advantaged schools.

In higher education, there are no comprehensive cross- and within-country statistics on the number of students who lack access to digital equipment at home that is adequate to learning needs. A 2018 study based on a non-representative survey of 748 students in U.S colleges found that 20% of students had difficulty maintaining access to technology, with higher incidence amongst students of lower socio-economic status and students of colour (Gonzales, McCrory Calarco and Lynch, 2018[18]). More recent large-scale survey evidence for the United States in 2020 showed that about one in four higher education students experienced device issues including outdated devices that could not support the needed software and apps, and having to share a device (Brooks and Gierdowski, 2021[19]). In the United Kingdom, a 2020 study on 1 416 higher education students showed that 18% were impacted by lack of access to a computer, laptop or tablet and 56% lacked access to appropriate online course materials (Office for Students, 2020[20]).

Divides also persist in students' access to education software and learning platforms

Digital devices are the first step to accessing an ever-increasing number of digital tools and services. Digital education platforms, education software and learning apps are a few examples of tools upon which students can rely. Around half of EU students at lower secondary level had access to a VLE at school before the pandemic and most of them could access the VLE outside of working hours or outside the school premises (European Commission, 2019[12]). However, differences in access across countries are evident – no more than 15% of students had access to VLEs in Croatia, Greece, Hungary and Romania, in contrast to more than 90% in Finland and Sweden.

Before the pandemic, the share of students with access to education software at home had stagnated across countries with available PISA data. In 2018, 58% of 15-year-olds in OECD countries had access to education software at home, with students from socio-economically advantaged schools displaying substantially higher levels of access (OECD, 2019[8]). As learning moved outside of school premises during the pandemic, education technologies targeted directly at students or their parents (rather than at formal education institutions) experienced a rise in demand (HolonIQ, 2020[21]). However, as in the pre-pandemic period, socio-economically advantaged students who could afford to purchase such software are likely to have had greater access to these technologies except where government schemes supported students' access.

Advanced technologies are not yet commonplace in education systems

Beyond standard or traditional digital equipment (e.g. digital devices), education systems increasingly have access to a range of new and more advanced digital tools and products developed by EdTech companies (e.g. Augmented Reality, Virtual Reality, AI, robotics and blockchain). Despite their potential for transforming education in schools and classrooms, such technologies have not become mainstream in education systems yet. In fact, the gap between the technology available to most education stakeholders and the most advanced, forward-looking types of technology remains wide (Vincent-Lancrin, Cobo Romaní and Reimers, 2022[22]).

There are many reasons for this slow adoption of the most advanced education technologies. Firstly, their adoption can be prohibitively expensive for many education institutions. For example, virtual and augmented reality implementations require the purchase of costly specialised equipment and software, while the integration of advanced robotics requires both the purchase of robotic equipment and the availability of staff trained in its programming and use.

Furthermore, as discussed earlier in this report, AI-based software is raising ethical dilemmas within education systems, and there is increasing awareness of the need to carefully monitor the impact of the use of AI and algorithms in education settings. Education institutions and policy makers also face a steep learning curve in understanding the strengths, weaknesses, opportunities and challenges posed by AI (Holmes et al., 2022[23]). For example, the emergence of advanced generative AI chatbots has sparked widespread deliberations about the implications for education systems, in terms of impact on students skill development, assessment processes, and the definition of learning goals and curricula (Dwivedi et al., 2023[24]).

Finally, it should be noted that the adoption of advanced technologies can further widen inequalities between students of different backgrounds if these are more likely to be accessed by socio-economically advantaged education institutions or students, who also likely benefit from better digital technologies conditions, and better-prepared teachers and school leaders. Research evidence suggests that even for relatively less novel or advanced technologies, such as school-to-parent communication technologies, equity considerations are critical as technology adoption is higher among the most advantaged families (Bergman, 2019[25]).

Policy makers and educators are therefore concerned with how to harness the potential benefits of advanced technologies while mitigating its risks and the scale of investment required. However, the number of use cases for such advanced technologies is continuously increasing (Educause, 2022[26]) providing more opportunities to learn from existing practices.

Cloud services are fast becoming mainstreamed, but adoption of cloud technologies in education systems is uneven

Cloud services including cloud storage, Infrastructure as a Service, and Software as a Service have not been rapidly adapted in education. Suppliers of core software have moved to Software as a Service models of delivery: for instance the four main global VLEs – Canvas, Brightspace, Blackboard, and Moodle are already cloud-hosted and supported, or are rapidly moving towards that model. While many education institutions have remained reluctant to 'lose control' of their software, the pandemic showed that on-premises server capacity cannot handle an unexpected large surge in demand, thus creating disruptions in learning when capacity is limited.

The potential of cloud services to bridge inequality in access relies on having access to fast and reliable network connectivity. Cloud services can be accessed anywhere (i.e., they are location-independent), benefit from economies of scale, reduce the need to run local IT services, and grant access to many independent users to better and more varied portfolio of resources (Géant, 2020[27]). Digital divides in broadband infrastructure mean institutions located in areas of poor connectivity will fall behind in the transition to the cloud and its benefits.

Further investments are needed in the innovation of education technologies

Education technology venture capital funding has surged since the pandemic, but investment in digital innovation for education is likely insufficient

Achieving the potential of digital technologies in education requires providing access to quality digital technologies to all students and educators. In turn, this demands significant investments to develop the innovative tools, products and services that can truly enhance learning outcomes. Investors in the EdTech market span a spectrum of organisations, including philanthropic foundations, venture capital, government and government intermediaries as well as idea incubators (e.g. EdTech competitions) (Escueta and Holloway, 2019[28]). However, systematic data on the amounts invested in education technology by most investor types are often lacking, with most existing evidence focusing on venture capital investments in education technology (hardware, software and technology-enabled services). Governments can also intervene by injecting public resources in venture capital markets.

Disaggregated data on government-sponsored venture capital in education technology is not available. Yet, available data on venture capital investments show that over the past decade, venture capital has become increasingly involved in the funding of R&D for digital technologies that are acquired by education and training systems. The pandemic triggered an almost threefold increase in education technology venture capital levels (HolonIQ, 2022[29]). This has been mostly led by a surge in European and United States investments in the area, whereas Asian countries led investment in education technologies worldwide before the pandemic. In addition, while education technology has traditionally supported formal education institutions, technologies, tools and services that directly target students, parents and workers have equally increased during the pandemic, triggering a rise in investment devoted to consumer-focused education products (HolonIQ, 2020[21]).

At the same time, education technology venture capital funding in European countries (14% of global education technology funding in 2021) remains lower than funding in other countries such as India (18%) or the United States (40%) (IDB and HolonIQ, 2021[30]). Overall, the size of the education technology industry remains moderate (for instance, in comparison to health), and education technology venture capital funding lags behind health technology and climate technology venture capital levels (HolonIQ, 2022[29]).

These figures prompt questions about the sufficiency of investment both on aggregate and relative terms (compared to other sectors and sometimes other countries). These questions are particularly relevant given the reliance of education systems on private actors in the development of tools, products and services for digital education, particularly in emergency contexts (Vincent-Lancrin, 2020[31]). A range of factors are likely to hold back investment and innovation in this sector, including regulatory frameworks in education systems, fragmented market demand for education technology, lack of incentives, insufficient access to capital and the geographic concentration of global venture capital investment. This should also be considered against the background of lagging digital innovation in Europe in general compared to the United States and a range of Asian countries (OECD ECOSCOPE, 2022[32]).

Another challenge for innovation in digital education technologies relates to the innovation-potential of venture capital. In European countries, only 2% (vs. 6% globally and 10% in East Asia) of the most promising start-ups in education technology[5] were founded during the pandemic[6] (HolonIQ, 2022[33]). Research evidence shows that venture capital tends to direct its investment focus towards less innovative start-ups during economic downturns (Howell et al., 2020[34]). During the pandemic, early-stage investments focusing on more innovative but also riskier start-ups declined relative to later-stage investments that targeted more mature education technology firms in order to support their rapid scale up (Dee, 2020[35]).

Promising approaches for establishing an equitable and innovative digital education infrastructure

Further invest in providing reliable connectivity for equitable digital learning opportunities

Beyond overarching policies to promote and facilitate broadband deployment and foster competition between providers, OECD countries have implemented policies to bring connectivity in areas not catered by markets including:

- co-ordinating, committing and bundling demand in rural areas;
- supporting public private partnership (PPP) initiatives; public funding to market players to expand connectivity in rural/remote areas through reverse auctions;
- supporting open access municipal and community-led networks and;

- providing "last mile" connectivity in rural and remote areas using technologies with less fixed costs such as fixed wireless access and including coverage obligations in auctions (OECD, 2021[36]) (OECD, 2021[37]).

In addition to policies targeting connectivity for all, governments have also worked on addressing poor internet connection in education institutions, by providing funding for broadband access and supporting access to fast and reliable internet connection in schools located in areas unlikely to benefit from commercial investment:

- In **Germany**, the Grey Spots Funding Programme has provided support for broadband roll-out in areas where commercial roll-out was not economically efficient (Federal Ministry for Digital And Transport, 2021[38]). The funds cover 50 to 70% of the costs of the gigabit roll-out and federal states also contribute to covering the costs. In 2021, the eligibility conditions for the Grey Spots Funding Programme were eased by adjusting the download bandwidth threshold for eligibility. A range of institutions, including schools, became eligible for funding, provided they did not benefit already from a very high-quality Internet connection.
- Through its digital centres initiative, **Colombia** invests an equivalent of USD 500 million to provide internet connection for learners in remove areas. Since 2020, the project has led to the creation of nearly six thousand digital centres - mainly based in public schools – which provide 24 hours internet access to rural communities (Ministry of Information Technologies and Communications of Colombia, 2023[39]).
- In the **United Kingdom**, the Rural Gigabit Connectivity Programme targets the delivery of gigabit connectivity in locations unlikely to be covered by commercial investment (DCMS, 2020[40]). The programme rests on two approaches. The Hub model approach identifies eligible public buildings and upgrades their connectivity, thereby enhancing its public service and potentially making the surrounding area more viable for commercial investment. A Rural Voucher approach targets the hardest to reach rural areas which can apply for a voucher in order to accelerate access to gigabit-capable connectivity. The Rural Gigabit Connectivity Scheme has also been used to identify schools (considered as hubs) in need of fibre connection and unlikely to benefit from it through commercial deployment.
- In the **United States**, the Federal Communications Commission E-Rate program has provided discounts to schools and libraries to support their access to affordable broadband services (Federal Communications Commission, 2022[41]). Schools can apply individually or through a consortium, to receive two categories of services: i) telecommunications, telecommunications services and Internet access and ii) internal connections, basic maintenance of internal connections and management of internal broadband services.

Other policy approaches and programmes increasingly focus on alternative solutions to bring connectivity to learners in areas without broadband and/or limited cell service. Indeed, while wired, wireless, fixed and mobile technologies can support the delivery of broadband connectivity, none of these technologies represents in itself the most appropriate option for all low-density and remote areas (OECD, 2021[42]). Prescribing specific technology solutions for bridging connectivity gaps in these areas may be less effective than maintaining an open approach to innovations and supporting technologies with growth potential in areas still reliant on legacy networks (OECD, 2021[42]). A range of programmes have leveraged or piloted the use of a mix of technologies to provide connectivity for learners or schools in very remote locations:

- As part of the Rural Access Gap program, the **New South Wales** government in **Australia** is investing in the infrastructure upgrade of rural and remote schools, in order to limit their dependence on satellite Internet and to close connectivity gaps with schools in urban areas. Schools in very remote areas benefit from upgrades through alternative technology, such as complex radio solutions coupled with buried and overhead fibre optic cable connections (NSW Government, 2022[43]).

- The **Massachusetts** Department of Elementary and Secondary Education (**United States**) established a partnership with a wireless network operator and a public school district to identify novel connectivity solutions for learners in rural areas lacking broadband access and having almost no cell service available. The Rural Internet Pilot Program showed that a mix of user-friendly tools that were easy to set up and deploy, and involved relatively low costs, provided effective solutions for the majority of households lacking Internet access (Massachusetts Department of Elementary and Secondary Education, 2021[44]).
- Also in the **United States**, the Coachella Valley Unified School District, which has a large proportion of students underneath the poverty line, equipped its school buses with solar powered WiFi-routers. Not only do these buses allow students to access the Internet during transit, once out of service the buses are also parked in underserved communities to provide broadband coverage.

Efforts have also focused on broadening off-site connectivity for learners. During the COVID-19 pandemic, countries have supported families who lack Internet access and data package subscriptions to ensure connectivity for learners of different backgrounds (Vincent-Lancrin, Cobo Romaní and Reimers, 2022[22]). In almost half of the countries covered by an OECD/UNESCO-UIS/UNICEF/World Bank Special Survey on COVID-19, measures targeting populations at risk of exclusion from distance education platforms included agreements with Global System for Mobile Communications operators/Internet firms to remove Internet access barriers (OECD, 2021[45]).

To keep track of inequality in access for students, policies can mandate or co-operate with education institutions to keep detailed registration data to help identify and support at-risk students, including those from lower socio-economic backgrounds and/or those living in poor broadband coverage areas. Policies can also support institutions providing support for students with poor access. For instance, in **New Zealand**, the Ministry of Education is providing guidance on how schools can become “Digital Hubs” that provide broadband access to their communities, and runs a number of pilots in co-operation with telecommunication companies, schools and community trusts to co-create solutions for students lacking Internet access (Ministry of Education, 2021[46]).

Higher education institutions in general are less likely to be located in areas with limited Internet access, compared to schools. The large capacity already installed to satisfy the links between higher education and research institutions to the NREN backbone network[7] makes it in principle possible for schools and VET institutions to benefit from the existing installed capacity. About half of NRENs in Europe can also connect schools and in fact schools were the fastest growing type of user for NRENs in 2019-2020 (Géant, 2022[47]). Schools and VET institutions are more likely to use NRENs for their connectivity needs in countries where NRENs dominate connectivity provision for higher education and research, which also coincides with cases where NRENs are mostly publicly funded (Géant, 2020[27]).

However, higher education institutions and policy makers still need to tackle digital divides in the home environment of their students. In some cases, as, for example, in the Community College of Aurora in the **United States**, higher education institutions are liaising with local leaders and community stakeholders, in order to encourage greater focus on improvements to the local digital infrastructure, and therefore improve the opportunities for students to access connectivity and other digital technologies off-campus (Pressley, 2022[48]).

Ensure sufficient and equitable access to quality digital equipment and tools

Bridge digital equipment gaps in education institutions

While the pandemic has shifted the focus of debates on digital equipment to private households, education systems have largely returned to in-person teaching, bringing renewed focus to digital equipment on the premises of education institutions. In this context, the disparities in digital equipment between education institutions which re-enforce access gaps between socio-economic groups and were highlighted in previous sections become once again critical. This calls for further investments to bridge gaps in digital infrastructure access but also to ensure the adequacy and quality of digital equipment overall. In fact, several countries have made significant investments in digital equipment over recent years with the intention to improve digital facilities for disadvantaged education institutions and students.

- For instance, the ICT Grant scheme in **Ireland** allocates a total of EUR 200 million to schools to purchase digital equipment between 2021 and 2027. The funding is based on a flat rate lump sum and a per capita amount per student enrolled. To narrow digital divides, the scheme further includes adjusted per capita rates for special need schools and schools that are part of the government's "Delivering Equality of opportunity in Schools" Programme – a scheme targeting 1 194 schools in Ireland with a high concentration of students at risk of educational disadvantage (Department of Education Ireland, 2022[49]; Department of Education Ireland, 2022[50]).
- Also in **Ireland**, during the pandemic, the Government Laptop Loan scheme provided funding for students from priority target groups (such as students with socio-economic barriers, disabled students and first-time mature students) in further and higher education institutions to cover the cost of the institution buying a laptop and loaning them to students for the duration of the studies. The scheme has been continued into the post-pandemic period (Department of Further and Higher Education, 2020[51]).
- COVID-19 recovery strategies have in some countries included new investments into the digital infrastructure of higher education institutions. For instance, the **United Kingdom** committed GBP 200 million to improve physical and digital infrastructure in more than 180 further education colleges in 2020 (FE News, 2020[52]).

With the upward trend of ownership and use of end-user hardware in the home (OECD, 2022[53]), some education institutions have turned to a Bring Your Own Device (BYOD) strategy to bridge equipment gaps. BYOD policies vary significantly across schools in terms of the eligibility requirements for different devices: While some schools simply advise students to bring their own devices other "managed" BYOD programmes require students to lease or purchase specific recommended laptop models or tablets (Burns and Gottschalk, 2019[54]). This can in principle reduce institutions' capital outlay and simplify and enhance the user experience. However, not all students have adequate digital technology at their disposal. Even where students have access to digital devices at home the sharing of devices among family members, or inadequate device quality (e.g. battery life or incompatibility with specialist software) might render these devices unfit for use in school. In addition, BYOD as a substitute for institutional equipment only works if personal devices can interoperate with the main institutional systems. Personal devices might lack required safeguards leading to privacy and security issues (van der Vlies, 2020[55]).

Combining BYOD approaches with central provision of digital devices might be a promising step to address these concerns whilst leveraging existing privately owned tools:

- For instance, **New Zealand** has traditionally relied strongly on BYOD policies at schools, with 55% of schools already having implemented BYOD for students in 2018. However, despite the salience of BYOD policies, 86% of schools also maintain pooled devices to provide alternatives to students who lack access to adequate personal devices (IDC, 2018[56]). A further 36 000 devices were made available to high-priority learners during the COVID-19 pandemic (Dowden, 2022[57]).
- In **Greece**, a voucher scheme for IT equipment was targeted particularly to students from low-income families and teachers (Danielienė, 2020[58]). As part of the scheme, more than 665 000 vouchers were given out to teachers and disadvantaged students between the age of 4 and 24.
- Similarly, BYOD policies might be limited to certain parts of the student population. For instance, a school district from Cincinnati (**United States**) has required students in upper grades to bring their devices, whereas younger students benefitted from a 1:1 programme (Office of Educational Technology, 2017[59]). The district also provided devices (for school use only) to those students who lacked a personal device.

As access to personal devices is not universal, 1:1 learning initiatives seek to provide all students with access to digital devices. In recent years, these device policies have increasingly leveraged portable devices thus enabling students to use digital devices both in schools and at home. Plan Ceibal in **Uruguay** arguably represents the earliest and most extensive example of a 1:1 programme. Between 2006 and 2009, laptops and free of charge Internet access were provided to all students and teachers at public primary and lower secondary schools (Ceibal, n.d.[60]). Efforts in consecutive years concentrated on strengthening teachers' and institutions' capacities and promoting adequate pedagogies for digital education. Whilst Plan Ceibal is one of the first examples of a coherent, nation-wide 1:1 programme that reduced divides in access to digital equipment and supported the uptake of Internet services in households, the systematic distribution of digital devices to students has become increasingly common in many education systems (Díaz, Dodel and Menese, 2022[61]).

While students have often been the focus of digital devices distribution programmes, teachers' access to digital technologies should equally be ensured. Evidence on teachers' access to school computers connected to the Internet (and available for teachers) shows strong cross-country variability (OECD, 2020[62]). However, little is known on the extent to which teachers have access to quality digital equipment (and connectivity) at home. During the pandemic, more than two-thirds of countries covered by a special OECD/UIS/UNESCO/UNICEF/World Bank Survey, provided digital tools (e.g. PC, mobile devices) or free connectivity (e.g. vouchers for mobile broadband) to teachers (OECD, 2021[45]). Documenting teachers' access to quality digital equipment and supporting teachers who lack access to necessary digital tools is a key precondition for successful digital education.

Another potentially relevant area for policy intervention relates to the development and maintenance of databases of available education technology tools/services and their use. Collecting data on the diversity of digital tools and particularly software available for student learning has proven challenging, in light of fast technological advances in the field and the lack of measurement tools. Data on penetration of advanced technologies (e.g. AI-based education tools) across education systems is particularly limited. Finally, data on the types and quality of equipment that education systems and institutions have for students with special education needs remain generally absent, with the exception of anecdotal examples or case studies. Monitoring the availability of specialised equipment for students with special education needs is required to ensure all students can access the necessary and appropriate digital equipment and tools.

During the pandemic, partnerships between education institutions as well as between private companies and the public sphere proved essential in mobilising resources and finding technical solutions to deliver distance learning (Vincent-Lancrin, Cobo Romaní and Reimers, 2022[22]). Developing and supporting these collaborative efforts beyond the pandemic can continue to bridge inequalities in the access to digital equipment. For instance, partnerships between education institutions can provide a means for pooling resources for infrastructure in cases where single education institutions do not have the appropriate digital infrastructure individually. In higher education, several countries in Europe have developed framework agreements for HEIs to purchase equipment collectively, and some countries have established co-operative structures that promote collective digital planning and technology acquisition (OECD, 2023[63]). In addition, public-private partnerships can be established at different levels of the system, for the purpose of infrastructure provision, mobilisation of financial or human resources or the delivery of support by IT experts in schools or more generally. For instance, **Estonia** has built a long-standing co-operation with the private sector, developing e-services for education openly to enable the private sector to also bring its contribution and be involved from the early stages in the development of tools (Education Estonia, 2021[64]).

At the same time collaboration with the private sector raises a series of questions, which have become more salient in the context of the pandemic, most notably with respect to the protection of student data collected through digital tools or platforms (see Chapter 4).

Promote access to digital devices at home

Despite an increasing return to in-person teaching, the pandemic has irrevocably changed the character of learning, making online learning management systems, virtual learning environments and online communication between teachers, parents and students essential components. As these new ways of learning will continue to play a substantive role after the pandemic, it remains crucial to bridge gaps in access to digital devices at home.

Even before the pandemic, many national policies sought to provide students with portable devices for learning (Conrads et al., 2017[65]):

- The Yo Elijo Mi PC programme in **Chile**, the Home Access Programme in **England (United Kingdom)** or the EURO 200 programme in **Romania** are examples of government schemes that provided computers to students from socio-economically disadvantaged backgrounds, or supported them through grants or subsidies in acquiring a device (Bulman and Fairlie, 2016[66]; Escueta et al., 2017[67]).
- Though less common, the pandemic has also triggered the launch of some programmes to provide access to digital devices for higher education students. For instance, **Ireland** offered a one-off EUR 17 million COVID-19 Grant to support disadvantaged higher education students in accessing digital devices and an additional EUR 10 million for access supports (Government of Ireland, 2020[68]).

Co-operations with the private sector have also proved useful in bridging access to digital equipment for learning. During the pandemic, central governments have worked with a range of stakeholders (e.g. schools, municipalities, statistics institutes) and private sector actors (e.g. EdTech companies, non-profit organisations, telecom firms) in collective efforts to address inequalities in students' access to digital equipment and tools (Vincent-Lancrin, Cobo Romaní and Reimers, 2022[22]). For instance, in **Korea**, the Ministry of Education co-operated with a range of stakeholders (e.g. private companies, local governments, Statistics Institute) to provide digital devices (and subsidised Internet subscription fees) to socio-economically disadvantaged students. In a range of countries, local authorities, private organisations or schools also played an important role in bridging equipment gaps at home (OECD, 2021[45]).

Ensure continuing efforts to build and maintain digital infrastructure in education in line with latest technological developments

Providing an enabling infrastructure for digital education is not a one-time effort. On the one hand, existing digital equipment requires continuous maintenance to remain functional. As new software or tools enter education institutions, upgrades of existing digital infrastructure might also become necessary to meet higher connectivity or computing capacity requirements. On the other hand, advances in digital technologies might provide the basis for new types of uses of digital tools in education (e.g. AI or blockchain). Some countries already provide examples for frontier uses of digital technologies education systems:

- In the **United Kingdom**, the Joint Information Systems Committee (JISC) launched a new national centre for AI in tertiary education in 2021 with the aim of delivering AI solutions to colleges and universities.
- In **Greece**, funding from the National Recovery and Resilience Plan was used to purchase 177 000 robotics kits for children between the ages of 4 and 15 (Kathimerini, 2022[69]).
- **Korea** marks an early example of introducing advanced technologies in its education system. Korea has progressively introduced AI in education since 2018, expanded software education in primary and middle schools, opened AI pilot schools and designated high schools to develop AI-based models for education (OECD, 2021[70]).

As discussed previously, not all uses of digital technologies succeed in improving learning outcomes and some uses of advanced technologies come with considerable ethical concerns. While new digital technologies should thus not be blindly adopted, performing horizon scanning and taking stock of technological developments is key to ensure that education systems make optimal use of digital technologies to enhance learning outcomes.

Boost investment and innovation in digital education technologies through a co-ordinated and multi-dimensional policy approach

Governments play a key role in providing the enabling conditions for investment and innovation in digital education technologies, either by supporting new firms to start and grow, or by providing targeted support to address the challenges faced by existing firms. Such policies can be crucial particularly in European countries that are currently lagging behind in technology creation for education systems compared to other countries (e.g. the United States). However, boosting digital innovation in education usually goes beyond the realm of education policy. Thus, a broader policy spectrum including small and medium-sized enterprises (SME) and entrepreneurship policies as well as structural factors such as insolvency regimes are relevant for fostering digital innovation. Broader policy approaches to foster innovation within the EdTech sector might include: i) targeting regulatory burdens for start-ups, ii) promoting diversified financing options for new entrants, iii) mobilising the private and public sector to support R&D for digital innovation, iv) incentivising innovation through tax-based credits and v) policy experimentation (OECD, 2020[71]).

While boosting innovation requires a multi-dimensional response, education authorities can support the creation of background conditions conducive to innovation in education technology. For instance, ensuring universal access to connectivity and appropriate equipment in education institutions and building the capacity to harness its potential, supports demand for innovative digital education technologies, and thereby creates incentives for research and investment in the sector. Several countries have launched specific support measures for the EdTech sector. These include support to access finance and investment, innovation funds and grants for digital education technologies development, support for education technology incubators or accelerators, and visa classes to attract technology specialists from abroad. Through these means governments can assist the development of sustainable and transformational digital technologies, tools and services where it requires long-term, higher-risk research that firms might otherwise be reluctant to invest in (OECD, 2017[72]).

There are several examples of countries or cities that have provided an array of public support measures to develop and sustain a dynamic EdTech sector:

- The Helsinki Education Hub in **Finland** provides support for EdTech entrepreneurship and new business including: support for international start-up businesses willing to enter the City of Helsinki, pre-incubator services (e.g. coaching to early-stage start-ups), access to the EdTech Incubator Helsinki programme and support for businesses seeking to enter international markets (Helsinki Education Hub, 2022[73]). The Hub rests on the close collaboration of the Economic Development Unit and the Education Division of the City of Helsinki and is currently financed by the City of Helsinki Innovation Fund. It benefits from co-operation with a range of partners including universities, private sector companies focused on digital technologies, the Finnish EdTech industry association, etc. (NewCo Helsinki, 2021[74]).
- In the **United Kingdom**, as part of the EdTech innovation programme built in partnership by the Department for Education and the National Endowment for Science, Technology and the Arts innovation foundation, the EdTech Innovation fund provided grants of more than GBP 1.3 million in total to 15 EdTech organisations between 2019 and 2021 (NESTA, 2022[75]). The grants were targeted at organisations working on technologies related to formative assessment, parental engagement, essay marking and timetabling to support their improvement, expand their reach and enhance the evidence base. In addition, the EdTech R&D programme funded and tested

improvements to adapt a range of education technology products to the shift to remote learning caused by the COVID-19 pandemic (NESTA, 2022[75]).

- In **France**, the Ministry of Education provides financial supports to eligible digital tools and digital learning content providers through its Édu-up initiative. Projects that propose a solution in the field of digital education resources can apply for grants up to EUR 70 000 (Ministère de l'Éducation nationale, 2023[76]).

Efforts can also focus on encouraging private investments in education technology development. Designing incentives for the private sector to invest in innovation for education requires understanding the structure and dynamism of the education technology market (World Bank, 2020[77]). While venture capital investments in education technologies have grown substantially in the last decade, the pandemic and previous economic downturns have shown that the most innovative education technologies do not always attract the largest investments (Dee, 2020[35]). Strategies to maximise returns on investment, based on scaling up rapidly by attracting a large user base, may lead firms and investments to favour existing or familiar technologies rather than more innovative and hence, potentially riskier, technologies (Reich, 2020[78]). Partnerships among diverse stakeholders can incentivise greater risk-taking in private technology investments. For instance, support for partnerships between start-ups, universities, industry, and government can facilitate business development and innovation by providing start-ups with opportunities for funding as well as equipment to test tools, services or products (OECD, 2019[79]).

Governments should also aim for better monitoring investment and developments in the EdTech industry. Currently, most evidence on the scale of the global digital education industry, the types of technologies that attract investment and the geographic distribution of investments stems from the private sector. The development of a more comprehensive monitoring infrastructure is required to gain a better understanding of the dynamics of the EdTech industry and of the market for education technology specifically, including the presence of potential market failures (Vincent-Lancrin, Cobo Romaní and Reimers, 2022[22]). Such an infrastructure would in turn allow better targeting of innovation-related policies for digital education technologies. Chapter 9 analyses more in depth the design of a monitoring and evaluation infrastructure for digital education.

Beyond promoting innovation of digital technologies, government action might also serve to steer education technology markets to better serve desired goals for education. Education technologies are often purchased with public resources, are accessed by vulnerable users and have a significant influence over learning outcomes. Governments should thus have strong interests in guaranteeing that education technologies provided on private markets serve the public good. In this context, some countries – such as **Estonia** – have launched extensive public-private partnerships to allow collaboration between companies and the public sector to realise the full potential of digital technologies for education (Education Estonia, 2021[80]).

Governments also need to encourage better collaboration between education and training institutions and developers of education technology to ensure that new tools and equipment actually match the needs of and contexts in which education institutions, educators and learners evolve (as discussed in Chapter 3). In particular, educators' involvement in the development of digital education technologies during the R&D process is crucial to ensure digital technologies are designed for users and with the needs of the learning ecosystem in mind.

Key messages

Education systems across the OECD and EU have seen large investments in digital infrastructure over the past decade. However, this chapter highlights significant gaps both with respect to the equitable access to digital infrastructure and the quality of digital infrastructure overall. In particular, socio-economically disadvantaged education institutions are less likely to benefit from an enabling digital infrastructure including high-speed Internet and functional digital devices. Overall, education institutions report significant challenges in ensuring the quality of digital equipment and advanced technologies (e.g. blockchain or AI) have only found limited use in most education systems.

The COVID-19 pandemic has further elevated equity concerns regarding digital infrastructure as students have become increasingly reliant on the availability of high-quality digital equipment and high-speed Internet at home. As students rely on digital tools for learning at home even after the pandemic, these issues remain relevant. This chapter thus highlights a range of initiatives that countries have taken to bridge connectivity gaps and supply digital devices to disadvantaged learners.

Going forward, the extent to which education provision can benefit from digital technologies heavily depends on innovative forces in private EdTech markets. Currently, many countries – particularly in Europe – face low levels of private investment in digital technologies and the pandemic has likely contributed to greater risk-adversity in EdTech investments. Governments can influence the dynamics of EdTech markets both through regulation and investment. This chapter thus presents promising initiatives taken in OECD and EU member countries – including public-private partnerships or EdTech incubators – which aim to strengthen the innovative capacity of EdTech markets and steer them to better cater education needs.

References

5G Observatory (2022), *Report: 5G coverage doubles in Europe*, https://5gobservatory.eu/report-5g-coverage-doubles-in-europe/ (accessed on march 2022). [7]

Bergman, P. (2019), "Nudging Technology Use: Descriptive and Experimental Evidence from School Information Systems", *Education Finance and Policy*, pp. 1-43, https://doi.org/10.1162/edfp_a_00291. [25]

Bulman, G. and R. Fairlie (2016), "Technology and Education: Computers, Software, and the Internet", in *Handbook of the Economics of Education*, https://doi.org/10.1016/B978-0-444-63459-7.00005-1. [66]

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. [54]

Ceibal (n.d.), *Ceibal*, https://ceibal.edu.uy/en/about-us/ (accessed on 6 March 2023). [60]

Conrads, J. et al. (2017), *Digital Education Policies in Europe and Beyond: : Key Design Principles for More Effective Policies*, Redecker, C., P. Kampylis, M. Bacigalupo, Y. Punie (ed.), EUR 29000 EN, Publications Office of the European Union, Luxembourg, https://doi.org/10.2760/462941. [65]

Cullinan, J. et al. (2021), "The disconnected: COVID-19 and disparities in access to quality broadband for higher education students", *International Journal of Educational Technology in Higher Education*, Vol. 18/1, https://doi.org/10.1186/s41239-021-00262-1. [9]

Danieliené, I. (2020), *560,000 low-income students to benefit from IT subsidy*, https://www.navinvestgreece.com/post/560-000-low-income-students-to-benefit-from-it-subsidy (accessed on 3 April 2023). [58]

DCMS (2020), *Rural Gigabit Connectivity Programme*. [40]

Dee, T. (2020), *VCs Are Pouring Money Into the Wrong Education Startups | WIRED*, WIRED, https://www.wired.com/story/vcs-are-pouring-money-into-the-wrong-education-startups/ (accessed on 7 April 2022). [35]

Department of Education Ireland (2022), *Grant Scheme for ICT Infrastructure – 2021/2022 School Year*, https://www.gov.ie/en/circular/e1f8e-grant-scheme-for-ict-infrastructure-20212022-school-year/ (accessed on 30 January 2023). [49]

Department of Education Ireland (2022), *Minister Foley announces €32 million major expansion of the DEIS programme incorporating 310 new schools*, https://www.gov.ie/en/press-release/71054-minister-foley-announces-32-million-major-expansion-of-the-deis-programme-incorporating-310-new-schools/ (accessed on 30 January 2023). [50]

Department of Further and Higher Education, R. (2020), *Minister Harris announces 17,000 laptops ordered to assist students with online and blended learning*, https://www.gov.ie/en/press-release/7143d-minister-harris-announces-17000-laptops-ordered-to-assist-students-with-online-and-blended-learning/ (accessed on 13 April 2023). [51]

Department of Further and Higher Education, R. (ed.) (2020), *Minister Harris announces 17,000 laptops ordered to assist students with online and blended learning*, https://www.gov.ie/en/press-release/7143d-minister-harris-announces-17000-laptops-ordered-to-assist-students-with-online-and-blended-learning/# (accessed on March 2022). [68]

Dettling, L., S. Goodman and J. Smith (2018), "Every Little Bit Counts: The Impact of High-Speed Internet on the Transition to College", *The Review of Economics and Statistics*, Vol. 100/2, pp. 260-273, https://doi.org/10.1162/rest_a_00712. [3]

Díaz, C., M. Dodel and P. Menese (2022), "Can one laptop per child reduce digital inequalities? ICT household access patterns under Plan Ceibal", *Telecommunications Policy*, Vol. 46/9, p. 102406, https://doi.org/10.1016/J.TELPOL.2022.102406. [61]

Dowden, A. (2022), "Provision of Internet Connectivity and Devices to Learners | Evaluation Report", https://www.educationcounts.govt.nz/__data/assets/pdf_file/0007/214468/Full-Report-Evaluation-of-Provision-of-Connectivity-and-Devices-A-Covid-19-Response.pdf (accessed on 28 February 2023). [57]

Dwivedi, Y. et al. (2023), ""So what if ChatGPT wrote it?" Multidisciplinary perspectives on opportunities, challenges and implications of generative conversational AI for research, practice and policy", *International Journal of Information Management*, Vol. 71, p. 102642, https://doi.org/10.1016/J.IJINFOMGT.2023.102642. [24]

Education Estonia (2021), *Three ways public-private partnerships are transforming education. Insights from Estonia*, https://www.educationestonia.org/education-public-private-partnerships-in-estonia/ (accessed on 18 May 2022). [64]

Education Estonia (2021), *Three ways public-private partnerships are transforming education. Insights from Estonia - Education Estonia*, https://www.educationestonia.org/education-public-private-partnerships-in-estonia/ (accessed on 13 April 2023). [80]

Educause (2022), *2022 EDUCAUSE Horizon Report | Teaching and Learning Edition | EDUCAUSE*, https://library.educause.edu/resources/2022/4/2022-educause-horizon-report-teaching-and-learning-edition (accessed on 8 July 2022). [26]

Educause (ed.) (2021), *Student Experiences with Technology in the Pandemic*, https://library.educause.edu/resources/2021/4/student-experiences-with-technology-in-the-pandemic (accessed on March 2022). [19]

Escueta, M. and S. Holloway (2019), "Investment in Education Technology Across the Globe: Where Profit Meets Purpose", *ENTREPRENEURSHIP & POLICY WORKING PAPER SERIES*, Columbia School of International and Public Affairs. [28]

Escueta, M. et al. (2017), "Education Technology: An Evidence-Based Review", http://www.nber.org/papers/w23744. [67]

European Commission (2021), *Digital Economy and Society Index (DESI) 2021*, https://digital-strategy.ec.europa.eu/en/library/digital-economy-and-society-index-desi-2021 (accessed on 2022). [5]

European Commission (2019), *2nd Survey of Schools: ICT in Education - Objective 1: Benchmark progress in ICT in schools*, Luxembourg: Publications Office of the European Union, https://digital-strategy.ec.europa.eu/en/library/2nd-survey-schools-ict-education-0. [12]

FE News (2020), *More than 180 colleges receive share of £200 million to bring building and digital infrastructure up to date*, https://www.fenews.co.uk/fe-voices/more-than-180-colleges-receive-share-of-200-million-to-bring-building-and-digital-infrastructure-up-to-date/ (accessed on March 2022). [52]

Federal Communications Commission (2022), *E-Rate - Schools & Libraries USF Program*, https://www.fcc.gov/general/e-rate-schools-libraries-usf-program (accessed on 12 April 2022). [41]

Federal Ministry for Digital And Transport (2021), *Broadband funding by the Federal Government*, https://www.bmvi.de/EN/Topics/Digital-Matters/Broadband-Deployment/Broadband-Funding-Programme/broadband-funding-programme.html (accessed on 20 April 2022). [38]

Géant (2022), *NREN service portfolios*, https://compendiumdatabase.geant.org/reports/nrens_services (accessed on March 2022). [47]

Géant (2020), *Compendium of National Research and Education Networks in Europe - 2020*, https://about.geant.org/wp-content/uploads/2021/12/Compendium_FINAL2.pdf. [27]

Gonzales, A., J. McCrory Calarco and T. Lynch (2018), “Technology Problems and Student Achievement Gaps: A Validation and Extension of the Technology Maintenance Construct”, *Communication Research*, Vol. 47/5, pp. 750-770, https://doi.org/10.1177/0093650218796366. [18]

Helsinki Education Hub (2022), *Home - Helsinki Education Hub*, https://educationhubhelsinki.fi/ (accessed on 13 April 2022). [73]

Holmes, W. et al. (2022), “Artificial Intelligence and Education: A critical view through the lens of human rights, democracy and the rule of law”, http://book.coe.int (accessed on 7 April 2023). [23]

HolonIQ (2022), *2022 Global Education Outlook (extract)*, https://www.holoniq.com/notes/2022-global-education-outlook/ (accessed on 7 April 2022). [29]

HolonIQ (2022), *Global EdTech 1000 - 2021 Stats*, https://www.holoniq.com/notes/global-edtech-1000-2021-stats-and-2022-applications-open/ (accessed on 7 April 2022). [33]

HolonIQ (2020), *Global EdTech market to reach $404B by 2025 - 16.3% CAGR*, https://www.holoniq.com/notes/global-education-technology-market-to-reach-404b-by-2025/ (accessed on 10 August 2020). [21]

Holslin, P. (2021), *How to Reduce Zoom Data Usage*, https://www.satelliteinternet.com/resources/how-to-reduce-zoom-data-use/. [1]

Howell, S. et al. (2020), “How Resilient is Venture-Backed Innovation? Evidence from Four Decades of U.S. Patenting”, https://doi.org/10.3386/W27150. [34]

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). [30]

IDC (2018), *IDC Education Study: Digital Education in Schools*, https://www.education.govt.nz/assets/Uploads/IDC-Education-Study-June-2018-Summary-Survey-Results.pdf (accessed on 30 January 2023). [56]

Kathimerini (2022), *Robotics kits for children in Greek schools*, https://www.ekathimerini.com/economy/1177793/robotics-kits-for-children-in-greek-schools/ (accessed on 3 April 2023). [69]

Massachusetts Department of Elementary and Secondary Education (2021), "Sustaining Progress in Access and Equity: EdTech Strategic Planning Guide", https://www.doe.mass.edu/edtech/ (accessed on 17 May 2022). [44]

Ministère de l'Éducation nationale (2023), *Le dispositif Édu-up*, https://eduscol.education.fr/1603/le-dispositif-edu (accessed on 3 April 2023). [76]

Ministry of Education (2021), *Home internet access – Education in New Zealand*, https://www.education.govt.nz/school/digital-technology/your-schools-ict-network/enabling-home-internet-access-for-your-community/ (accessed on 17 May 2022). [46]

Ministry of Information Technologies and Communications of Colombia (2023), *Digital Centers*, https://www.mintic.gov.co/micrositios/centros_digitales/768/w3-channel.html. [39]

Montacute, Rebecca; Holt-White, Erica (2020), *University Access & Student Finance*, The Sutton Trust, https://www.suttontrust.com/wp-content/uploads/2020/05/COVID-19-and-Social-Mobility-Impact-Brief-2.pdf. [10]

Mosley, N. (2022), *What's the current state of the VLE market in UK higher education?*, https://www.neilmosley.com/blog/whats-the-current-state-of-the-vlelms-space-in-uk-higher-education (accessed on 19 May 2022). [16]

NESTA (2022), *Reflections on the EdTech Innovation Partnership*, https://www.nesta.org.uk/project-updates/reflections-edtech-innovation-partnership/ (accessed on 10 April 2022). [75]

NewCo Helsinki (2021), *Helsinki Education Hub – flywheel for EdTech Startups*, https://newcohelsinki.fi/en/news/helsinki-education-hub-flywheel-for-edtech-startups/ (accessed on 13 April 2022). [74]

NSW Government (2022), *Better connectivity to close digital divide*, https://education.nsw.gov.au/about-us/strategies-and-reports/schools-digital-strategy/projects-and-initiatives/fast-reliable-and-secure-connectivity (accessed on 13 April 2022). [43]

Observatorio Nacional 5G (2022), *European homes with fiber optics have tripled in the last five years*, https://on5g.es/en/european-homes-with-fiber-optics-have-tripled-in-the-last-five-years/ (accessed on 13 April 2023). [13]

OECD (2023), *Advancing Digital Maturity in Croatia's Higher Education System*, OECD Publishing, Paris, https://doi.org/10.1787/26169177. [63]

OECD (2022), *Access to computers from home*, https://data.oecd.org/ict/access-to-computers-from-home.htm (accessed on March 2022). [53]

OECD (2022), *broadband portal*, https://www.oecd.org/digital/broadband/broadband-statistics/ (accessed on March 2022). [6]

OECD (2022), *Mending the Education Divide: Getting Strong Teachers to the Schools That Need Them Most*, TALIS, OECD Publishing, Paris, https://doi.org/10.1787/92b75874-en. [15]

OECD (2021), *Bridging digital divides in G20 countries*, OECD Publishing, Paris, https://doi.org/10.1787/35c1d850-en. [36]

OECD (2021), *Delivering Quality Education and Health Care to All: Preparing Regions for Demographic Change*, OECD Rural Studies, OECD Publishing, Paris, https://www.oecd-ilibrary.org/docserver/83025c02-en.pdf?expires=1652780875&id=id&accname=ocid84004878&checksum=868DCFBDB8F867D6817415B60B6F64BA (accessed on 17 May 2022). [42]

OECD (2021), *Delivering Quality Education and Health Care to All: Preparing Regions for Demographic Change*, OECD Rural Studies, OECD Publishing, Paris, https://doi.org/10.1787/83025c02-en. [37]

OECD (2021), *Education Policy Outlook 2021: Shaping Responsive and Resilient Education in a Changing World*, OECD Publishing, Paris, https://doi.org/10.1787/75e40a16-en. [70]

OECD (2021), *The State of Higher Education: One Year into the COVID-19 Pandemic,*, OECD Publishing, Paris, https://www.oecd-ilibrary.org/docserver/83c41957-en.pdf?expires=1652952184&id=id&accname=ocid84004878&checksum=0C4D6A51EDC4A0BE8FF007D090163208 (accessed on 19 May 2022). [17]

OECD (2021), *The State of School Education: One Year into the COVID Pandemic*, OECD Publishing, Paris, https://www.oecd-ilibrary.org/docserver/201dde84-en.pdf?expires=1632997342&id=id&accname=guest&checksum=AB7A563077A4309BB5207DC1BF8D8508 (accessed on 30 September 2021). [45]

OECD (2020), *OECD Digital Economy Outlook 2020*, OECD Publishing, Paris, https://www.oecd-ilibrary.org/docserver/bb167041-en.pdf?expires=1649407912&id=id&accname=ocid84004878&checksum=622C667A00E953D9887D14298488AF4C (accessed on 8 April 2022). [71]

OECD (2020), *PISA 2018 Results (Volume V): Effective Policies, Successful Schools*, PISA, OECD Publishing, Paris, https://www.oecd-ilibrary.org/docserver/ca768d40-en.pdf?expires=1612200121&id=id&accname=guest&checksum=E54D5229D27FF6FE5BC6DD9C9F36F420 (accessed on 1 February 2021). [11]

OECD (2020), *PISA 2018 Results (Volume V): Effective Policies, Successful Schools*, PISA, OECD Publishing, Paris, https://doi.org/10.1787/ca768d40-en. [62]

OECD (2020), *PISA 2018 technical background*, https://doi.org/10.1787/1b045c06-en. [81]

OECD (2019), *2018 Database - PISA*, https://www.oecd.org/pisa/data/2018database/ (accessed on 13 April 2023). [8]

OECD (2019), *Going Digital: Shaping Policies, Improving Lives*, OECD Publishing, Paris, https://doi.org/10.1787/9789264312012-en. [79]

OECD (2018), *PISA 2018 Database*, https://www.oecd.org/pisa/data/2018database/. [14]

OECD (2017), *OECD Science, Technology and Industry Scoreboard 2017: The digital transformation*, OECD Publishing, Paris, https://doi.org/10.1787/9789264268821-en. [72]

OECD ECOSCOPE (2022), *How can Europe catch up on its digital backlog?*, https://oecdecoscope.blog/2022/05/17/how-can-europe-catch-up-on-its-digital-backlog/amp/ (accessed on 17 May 2022). [32]

Office for Students (2020), *'Digital poverty' risks leaving students behind*, https://www.officeforstudents.org.uk/news-blog-and-events/press-and-media/digital-poverty-risks-leaving-students-behind/ (accessed on March 2022). [20]

Office of Educational Technology (2017), *Building Technology Infrastructure for Learning Building Technology Infrastructure for Learning*, U.S. Department of Education, https://tech.ed.gov (accessed on 21 April 2022). [59]

Pressley, J. (2022), *Bridging the Digital Divide & Digital Equity Gap in Higher Ed | EdTech Magazine*, https://edtechmagazine.com/higher/article/2022/03/understanding-digital-equity-gap-and-bridging-digital-divide-higher-ed-perfcon (accessed on 13 April 2023). [48]

Reich, J. (2020), *Failure to disrupt : why technology alone can't transform education*, Harvard University Press. [78]

Sanchis-Guarner, R., J. Montalbán and F. Weinhardt (2021), "Home Broadband and Human Capital Formation", *SSRN Electronic Journal*, https://doi.org/10.2139/ssrn.3772087. [2]

Skinner, B. (2019), "Making the Connection: Broadband Access and Online Course Enrollment at Public Open Admissions Institutions", *Research in Higher Education*, Vol. 60/7, pp. 960-999, https://doi.org/10.1007/s11162-018-9539-6. [4]

van der Vlies, R. (2020), "Digital strategies in education across OECD countries: Exploring education policies on digital technologies", *OECD Education Working Papers*, No. 226, OECD Publishing, Paris, https://doi.org/10.1787/33dd4c26-en. [55]

Vincent-Lancrin, S. (2020), *Coronavirus and the future of learning: Towards a new EdTech industry?*, OECD Education and Skills Today, https://oecdedutoday.com/coronavirus-future-learning-new-edtech-industry/ (accessed on 6 August 2020). [31]

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. [22]

World Bank (2020), *Innovation Ecosystem Knowledge Pack*. [77]

Notes

[1] According to the PISA 2018 technical background, "advantaged and disadvantaged schools are defined in terms of the socio-economic profile of schools. All schools in each PISA participating education system are ranked according to their average PISA index of economic, social and cultural status (ESCS) and then divided into four groups with approximately an equal number of students (quarters). Schools in the bottom quarter are referred to as "socio-economically disadvantaged schools"; and schools in the top quarter are referred to as "socio-economically advantaged schools" (OECD, 2020[81]).

[2] The percentage of variance in student performance explained by the PISA index of economic, social and cultural status was used as measure of inequity in performance. In a first step, the correlation coefficients between measures of material resources and inequity were computed. In a second step, the sign of the correlation coefficients was reversed (i.e., multiplied by -1) to simplify reporting (i.e., report correlation with equity instead of with inequity). (OECD, 2020[62]).

[3] Rather than physical infrastructure (e.g. building, grounds).

[4] The cluster analysis performed to derive the "digitally equipped and connected schools" profiles was based on schools' equipment provision, proportion of fully operational equipment, Internet speed at school and type of Internet access and indicators of access to digital content (European Commission, 2019[12]).

[5] HolonIQ (2022[33]) identifies promising start-ups based on a range of criteria including the attractiveness of the market in which they operate, the quality, uniqueness and demonstrated impact of their product, the expertise of the team, the financial health of the company and positive changes in the size of the company over time.

[6] These figures exclude the Baltic countries for which a separate share is computed and represents 12%.

[7] Backbone networks interconnect networks by providing a path for the exchange of information between different LANs or subnetworks.

7 Capacity building for digital education

This chapter explores efforts to build capacity for digital education among actors at all levels of the education system: educators, institution leaders, parents, students and administrators. In addition to common capacity challenges that impede the effective use of digital education technologies, the chapter presents some promising approaches to building digital capacity. This includes continuing professional learning for educators, strengthening institution leaders' ability to build a culture of digital education, and strengthening local capacity to support education institutions.

Introduction

Reaping the potential of digital education technologies to enhance teaching and learning calls for people who are empowered to put digital technologies to effective use. Empowerment requires two elements to be in place – *capacity* and *motivation*. Educators, institution leaders, parents, students and administrators – each in different ways – need opportunities to develop their capacity to effectively engage with digital technologies for teaching and learning. This chapter explores recent developments and challenges associated with countries' efforts to strengthen capacity for digital education at all levels of the education system. It also presents a range of promising initiatives aimed at supporting educators (individually and collectively), institution leaders, students, parents and administrators in the digital transformation of education. Chapter 8 will address in more detail how – in addition to strengthening the capacity of educators – policy makers can adapt human resource policies to encourage and enable educators to engage with digital education. This includes educators' career structures, job descriptions, working time arrangements and appraisal systems, all of which are important to ensure that educators have the incentives, time and resources to put their digital skills into practice.

To enhance teaching and learning using digital education technologies, educators need the capacity to integrate, optimise and transform digital resources in different pedagogical processes and activities (European Commission, 2020[1]; Redecker, 2017[2]). This requires educators to have sufficient Technological Pedagogical and Content Knowledge as well to be supported in using this knowledge to develop suitable context-specific teaching strategies (Ulferts, 2021[3]; Willermark, 2018[4]). To address this challenge, the chapter considers a range of policy levers to strengthen educators' capacity, ranging from their initial education and continuing professional learning (including the support of peer learning and communities of practice) to the structural supports that could encourage a more widespread take-up of digital education technologies in schools.

At the institutional level, the capacity to effectively incorporate digital technologies hinges on schools' access to digital technologies, effective leadership, and the extent to which their culture and policies support the effective integration of technology in teaching and learning practices (Costa, Castaño-Muñoz and Kampylis, 2021, p. 2[5]; Castaño Muñoz, Pokropek and Weikert García, 2022, p. 5[6]). This chapter therefore considers how governments can provide education institutions with guidance, support their leadership and strengthen their ability to engage in institutional improvement strategies in the area of digitalisation. In addition to educators' and institutions' capacity, the chapter considers how policies can strengthen digital capacity across the wider learning environment. This includes administrative capacity at the central and sub-central levels of government, but also – in the case of younger learners – parents and other stakeholders who can facilitate and shape students' engagement with digital technologies for learning at home.

Building capacity for the effective use of digital education technology raises several challenges, which this chapters seeks to address by taking stock of the available evidence and presenting promising approaches observed in OECD countries. Some of the key questions on this issue that policy makers need to consider include:

- How can teachers' skills for the effective use of digital technologies be strengthened during their initial education and continuing professional learning?
- How to support school leaders in self-evaluation and school improvement efforts focused on advancing the digital transformation of their schools?
- How to guide students in their use of digital technologies and strengthen the capacity of parents and caregivers to act as digital education facilitators?
- How can central and local administrations leverage the potential of digital education technologies and support schools in their use?

Recent developments and current challenges

Educators are increasingly confident in using digital technologies, but many would benefit from further training

School teachers' preparedness for digital education varies greatly across countries

Teachers who are confident in using digital technologies are also better placed to help their students acquire the skills they need to thrive in a digital world. There is a statistically significant positive relationship between teachers' problem-solving skills in technology-rich environments (as measured in the OECD Survey of Adult Skills – PIAAC) and students' performance in computer problem solving and computer mathematics, as measured by the OECD Programme for International Student Achievement (PISA) (OECD, 2019[7]). At the same time, teachers are currently less likely than other tertiary-educated adults to possess these skills (OECD, 2019, p. 180[7]; Boeskens, Nusche and Yurita, 2020[8]) and many report a need for further training in the use of digital technologies for teaching.

According to principals surveyed for PISA 2018, only 65% of 15-year-olds were enrolled in schools whose teachers had the necessary technical and pedagogical skills to integrate digital devices in instruction on average across OECD countries. This proportion ranged from 27% in Japan to 84% in Lithuania (OECD, 2020[9]).[1] This is concerning at a time when teachers are increasingly expected to work with data in the classroom and integrate technology in their pedagogical practices. Evidence from the International Computer and Information Literacy Study (ICILS) shows that teachers who were confident about their own ICT capability were more likely than their less confident colleagues to emphasise developing their students' ICT skills (Fraillon et al., 2014[10]).

Teachers in some countries have received limited preparation in the area of ICT skills, according to the 2018 OECD Teaching and Learning International Study (TALIS). Across the OECD, only 56% of lower secondary teachers had received training in the use of ICT for teaching as part of their formal education or training (ranging from less than 40% in Sweden and Spain to 70% or more in Türkiye, England (UK), Colombia, Chile and Mexico). This proportion was significantly higher among recent cohorts of teachers, which reflects the modernisation of initial teacher education (ITE) programmes. Nevertheless, in some countries, more than 25% of teachers who completed their ITE within five years of the survey reported not to have received training in the use of ICT for teaching (including the Czech Republic, Denmark, Portugal, Austria, Korea, Norway and Iceland) (OECD, 2019, p. 207[11]). Likewise, only 43% of OECD lower secondary teachers felt well or very well prepared to use ICT for teaching when they completed their initial education or training (ranging from less than 25% in Austria and Finland to 60% and more in Hungary, Slovenia, Chile, Türkiye and Mexico) (OECD, 2019, p. 207[11]).[2]

Many school teachers report a need for further training on digital technologies

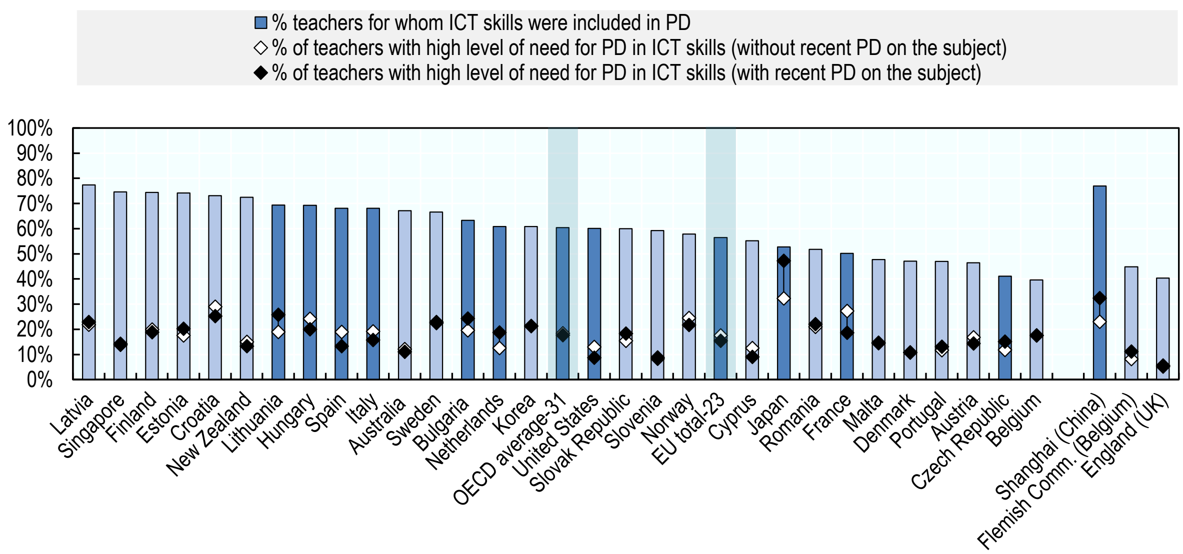
Continuing professional learning can help teachers to hone their practice and acquire skills that have not been covered by their initial teacher training. TALIS 2018 as well as the 2011/12 European Commission Survey of Schools in 27 European countries suggest that teachers use ICT in their classes more frequently and feel more confident in supporting students with digital technologies if they have received relevant training or regularly collaborated with their peers (OECD, 2020[12]; Minea-Pic, 2020[13]; European Commission, 2013[14]). Training is thus a critical factor in moving from the mere availability of digital technologies in schools to its actual use (Gil-Flores, Rodríguez-Santero and Torres-Gordillo, 2017[15]).

Although the proportion of teachers who participated in ICT-related professional development has increased in many countries since 2013, data from TALIS 2018 show that many teachers expressed a need for further training. In TALIS 2018, 60% of lower secondary teachers reported to have taken part in professional development activities on ICT skills for teaching during the past 12 months, on average across the OECD (57% across the EU). Among those who did, 17.6% reported a high need for further training on the subject – a proportion that was slightly larger (18.4%) among those who had not received ICT training over the past 12 months (Figure 7.1). At the lower secondary level, ICT skills for teaching were the second-most frequently cited area in which teachers had a high need for professional development (18% across the OECD, ranging from less than 8% in England [UK] and Türkiye to over 30% in Colombia and Japan) (OECD, 2019, p. 209[11]).[3]

As can be seen in Figure 7.1 teachers' participation in and need for ICT training varies significantly across OECD countries and other advanced economies participating in TALIS. While the association between teachers' participation in ICT-related professional development and their reported need for further training is negative in many countries, it is positive in other regions (including, for example, Japan and Shanghai). This may be because training raises teachers' awareness of their knowledge gaps or because teachers with high levels of need are more likely to seek out training (OECD, 2019[11]).

Figure 7.1. Teachers' participation in and need for professional development in ICT skills (2018)

Based on the reports of lower secondary teachers



Notes: Countries and economies are ranked in descending order of the proportion of teachers that engaged in professional development activities on ICT skills for teaching in the 12 months prior to the survey; Statistically significant differences between teachers for whom ICT skills for teaching was included in their professional development activities and teachers for whom it was not included are displayed in a darker tone.
Source: OECD (2019[11]), *TALIS 2018 Results (Volume I): Teachers and School Leaders as Lifelong Learners*, https://doi.org/10.1787/1d0bc92a-en, Table I.5.24.

Educators in VET and higher education also need further training to build their capacities for digital education

Building capacity for digital education is also an important concern for the VET sector. In light of rapidly digitalising work environments, VET teachers need to equip their students not just with vocational but also with digital skills in order to facilitate their transition into the labour force and enhance their adaptability. The use of robots, virtual reality (VR), augmented reality (AR), simulators and other innovative technologies are likely to become more common in VET in the years to come. Teachers' effective use of these technologies promises to foster students' vocational and digital skills at the same time and may increase flexibility, safety and efficiency in VET (OECD, 2021, p. 120[16]).

The use of digital technologies in VET education is already widespread. In the six OECD countries and regions with available data from the 2018 TALIS survey[4], 74% of upper secondary VET teachers reported using digital technology with their students, compared to 66% of general education teachers (OECD, 2021, p. 131[16]). Data from the European Commission's SELFIE further suggest that VET teachers are slightly more likely than general education teachers to report using digital tools for teaching (OECD, 2021, p. 132[16]; Hippe, Pokropek and Costa, 2021[17]). However, a large proportion of VET teachers lack sufficient skills to teach in digital environments. In 2018, 46% of upper secondary VET teachers in the countries and regions with available data reported that ICT skills were the area in which they were most in need of training (OECD, 2021[16]).

At a higher education level, very limited comparative data are available on the training needs of educators regarding their use of digital technologies. Many HEIs were ill prepared for the sudden switch to emergency online delivery in 2020. At the outset of the COVID-19 pandemic, a relatively small share of higher education programmes were delivered substantially or fully on line, and even in digitally intensive systems, such as the United States, less than half of educators (46%) reported that they had previously taught a course on line (Jaschik and Lederman, 2019[18]). Many educators thus considered the rapid shift to online education to be challenging (OECD, 2021[19]).

However, available evidence suggests that the pandemic also led to an acceleration and deepening of digitalisation in teaching and learning (OECD, 2021[19]). For example, research conducted in a Polish university (Ejdys and Kozlowska, 2021[20]) just before the pandemic and then repeated a year later showed that the use of e-learning by both students and teachers had increased, as expected. Both students and teachers reported that their ability to solve problems in the online environment had improved. However, with an increased share of their teaching being undertaken on line, teachers rated both the ease of use and their understanding of procedures and instructions lower, once they were forced to use e-learning for all or most of their teaching (Ejdys and Kozlowska, 2021[20]).

In most OECD and European higher education systems, training in teaching or participation in professional development is not mandatory for academic staff (OECD, 2019[21]), (Eurydice, 2017[22]). Where teaching qualifications do exist, the associated curriculum or training activities are often developed by individual higher education institutions, making it difficult to ascertain the extent to which digitally enhanced teaching is emphasised. At the same time, many studies highlight the need for more capacity building for digital education within higher education systems. For instance, a survey of the digital experiences of students in post-secondary education in the United Kingdom showed that many educators struggle with technology and lack confidence in their ability to manage technology well; students reported that the most important thing institutions could do to help learning would be to help teaching staff to become more skilled in technology use (Ghurbhurun, 2020[23]).

Higher education educators themselves are also aware of the need to improve their competence in the use of digital technologies. A recent systematic literature review of the digital competence of teaching staff in higher education concluded that educators self-identify as having low to medium digital competence, with particular weaknesses in areas such as evaluation of educational practice, solving problems using digital technologies and working collaboratively on digital education within a network of contacts (Basilotta-Gómez-Pablos et al., 2022[24]). Interviews with higher education educators also indicate that many of those who have integrated digital approaches into their teaching have done so with little awareness of how technology can support teaching and made limited use of evidence from the research literature on teaching practices (Martin et al., 2020[25]; Price and Kirkwood, 2014[26]).

A lack of capacity among educators limits the benefits of education technology for students with special education needs

As discussed in Chapter 1, the effective use of digital technologies can enable teachers to provide more differentiated forms of instruction and to cater to students with special education needs (SEN) with the help of digital assistive technologies. In TALIS 2018, 22% of teachers across the OECD reported a high level of need for further training on teaching students with SEN – the most widely reported training need. Teachers' limited capacity to use digital technologies in the classroom may contribute to or exacerbate their difficulty in teaching students with SEN, which raises concerns for equity and inclusion (OECD, 2019, p. 209[11]). Analyses from the United States also point to a lack of exposure to digital assistive technologies in teachers' pre-service training and suggest that a significant proportion of special education teacher education programmes do not include mandatory modules on the use of digital technologies to support students with SEN (Atanga et al., 2020[27]).

Although no international comparative data on the use of digital assistive technologies is available, TALIS 2018 data show that – in some education systems – teachers in schools with a high share of students with SEN make greater use of digital technology for instruction. In Alberta (Canada), New Zealand, Singapore and the United Arab Emirates, for example, the share of teachers who use ICT for teaching on a regular basis is 3 to 12 percentage points higher in schools where more than 10% of students have SEN. By contrast, in Croatia and Hungary, the share of teachers who reported "frequently" or "always" letting students use ICT for projects or class work is 6 percentage points lower in schools where the concentration of students with SEN is above 10% (OECD, 2022, p. 103[28]).[5] Digital technologies can also be used to widen access to higher education for students with SEN. To do so effectively, HEI staff need training and support in the use of assistive technologies (Asselin, 2014[29]).

Widening access to higher education for students with physical impairments and learning disabilities requires not only a focus on physical access and technological support, but also different approaches to pedagogical practices, assessment and evaluation (Hanafin et al., 2007[30]). In addition, technologies can create barriers and challenges for students with disabilities due to the inaccessibility of digital tools and learning materials and because staff need support to use those tools in ways that provide effective support to students with physical impairments and learning disabilities (Bong and Chen, 2021[31]). In the **United States**, a survey of university support workers during the pandemic suggested that students with physical impairments and learning disabilities found the move to wholly remote delivery of higher education more difficult than other students (Scott and Aquino, 2020[32]). Research into this topic suggests that instructional staff need to receive training on assistive technologies and pedagogical approaches such as universal design for learning to implement them effectively (Bong and Chen, 2021[31]).

Education institutions demonstrate varying capacities to effectively engage with the digital transformation

Variation among schools' and school leaders' capacity to engage with the digital transformation of education poses equity challenges

The successful digital transformation of schools requires strong institutional capacity and a strategic approach to school improvement and whole-school development. School leaders play a critical role in managing this transition successfully and bringing their teachers on board to embrace the effective use of digital education technologies. This requires not only a motivation to embrace change, but also the skills and resources necessary for principals to engage in instructional leadership, i.e. taking purposeful actions to promote students' learning.

Effective school leaders set normative expectations, support teachers in trying out new teaching practices, help them to collaborate on shared problems and encourage them to implement what they have learned in professional development (Goddard et al., 2015[33]; OECD, 2022, p. 61[28]). Previous evidence from TALIS showed that principals who received training in instructional leadership were more likely, for example, to support co-operation among teachers to develop new teaching practices (OECD, 2014[34]). A number of countries – Finland, Latvia, Portugal, Singapore, the Slovak Republic and Spain – appear to have made progress in this regard and significantly increased the proportion of principals that were trained in instructional leadership between 2013 and 2018 (OECD, 2020, p. 137[35]).

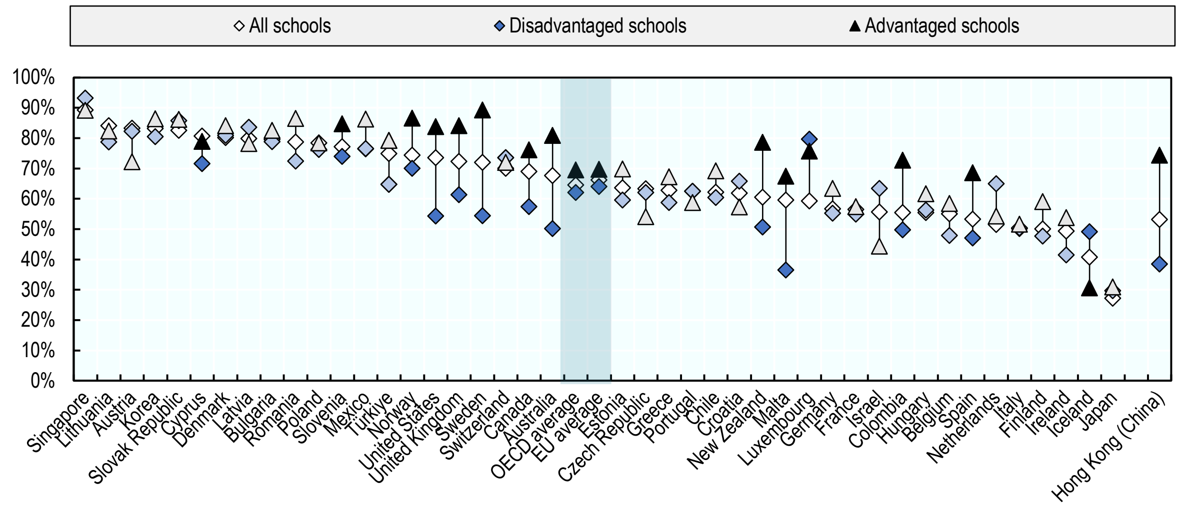
A resistance to innovation can constitute an important barrier to the adoption of new pedagogical approaches and changing a school's culture to embrace digital teaching and learning is a difficult task for school leaders. In TALIS 2018, school leaders have tended to report a greater openness to innovation than their teachers (85% across the OECD and the EU agreed that their school "readily accepts new ideas") (OECD, 2019, p. 205[11]). Likewise, teachers under age 30 were more likely to feel that their colleagues are not sufficiently open to change (OECD, 2019, p. 205[11]). To foster a school environment open to new ideas, leaders can encourage work in school-based professional learning communities to proactively identify needs for change and make assistance available to support teachers in the process of change (OECD, 2019, p. 31[11]). In TALIS 2018, teachers' openness to innovation appeared to be lower in many European countries than in other parts of the world. On average across OECD countries with available data, 74% agreed that most teachers in their school are open to change (compared with 72% across the EU). The proportions were particularly low in Portugal (59%), Belgium (61%) and the Netherlands (67%) (OECD, 2019, p. 205[11]).

Principals seeking to lead their schools towards the effective integration of digital education technology have to contend with widely diverging levels of resources and existing capacity. In TALIS 2018, on average across OECD countries, 27% of school leaders reported that a shortage or inadequacy of digital technology was hindering the provision of quality instruction. This proportion ranged from 5% or less in Iceland and Slovenia to more than 50% in Portugal and Colombia (OECD, 2020, p. 205[35]). Such a shortage of ICT resources in schools can limit teachers in their ability to enhance their teaching with the help of digital technology.

PISA 2018 data also suggest significant heterogeneity within countries when it comes to schools' capacity to use ICT for teaching and, in some cases, systematic inequities between advantaged and disadvantaged schools. On average across the OECD, the principals of 15-year-olds in socio-economically advantaged schools were 7 percentage points more likely than those in disadvantaged schools to report that their teachers had the necessary technical and pedagogical skills to integrate digital devices in instruction. On average across the EU, this discrepancy was slightly lower, at 6 percentage points, particularly pronounced in Sweden (35%), Malta (31%) and Spain (22%) (see Figure 7.2).

Figure 7.2. School's capacity to enhance teaching and learning using digital devices (2018)

Percentage of students in schools whose principal agreed or strongly agreed that teachers have the necessary technical and pedagogical skills to integrate digital devices in instruction



Notes: The socio-economic profile is measured by the PISA index of economic, social and cultural status (ESCS). A socio-economically disadvantaged (advantaged) school is a school in the bottom (top) quarter of the index of ESCS in the relevant country/economy; Statistically significant differences between advantaged and disadvantaged schools are marked in a darker tone; Countries and economies are ranked in descending order of the percentage of students in schools where teachers have the necessary technical and pedagogical skills to integrate digital devices in instruction.

Source: OECD (2020[9]), *PISA 2018 Results (Volume V): Effective Policies, Successful Schools*, https://doi.org/10.1787/ca768d40-en, Tables V.B1.5.15 and V.B1.5.16.

In many schools, teachers appear to lack the resources to learn how to use digital devices. Across the OECD, only 65% of 15-year-old students attended schools whose principal agreed that there were sufficient professional resources for teachers to learn how to use digital devices. Across the EU, the average stood at 67%, ranging from 29% in Hungary and 41% in Germany to more than 80% in Denmark, Sweden and the Czech Republic. Again, the perceived lack of professional resources was more acute in disadvantaged schools, on average (OECD, 2020, p. 266[9]; OECD, 2020[36]). On average across the OECD, socio-economically advantaged schools also had a higher share of teachers with high self-efficacy and confidence in their ability to support learning using ICT (OECD, 2022, p. 28[28]).

Increased autonomy in the higher education sector can lead to fragmentation of the development of digital capacities, and uneven progress across and within institutions

The COVID-19 pandemic exposed the extent of differences in digital capacity between higher education systems across the world, with some groups of institutions to move relatively seamlessly to fully online provision using digital tools, and others demonstrating very limited capacity to do so (Crawford et al., 2020[37]). In most OECD jurisdictions, HEIs enjoy a high level of autonomy to make decisions on staffing, finances, organisational structure and in academic matters (Kupriyanova, Bennetot Pruvot and Estermann, 2020[38]). The faculties and departments of the institution and to the individual academics employed in them will also have more autonomy to design their education offers than is the case in schools (OECD, 2020[39]).

As a result, governments have recourse to fewer policy tools to boost HEIs' capabilities. For instance, in many cases, they cannot set training requirements for staff, unlike in the school sector. Academic advancement and salary settings are also often outside the power of governments. Therefore, governments must rely on influence and incentives to encourage HEIs to increase digital capacity.

As discussed in Chapter 6, higher education institutions in European countries are increasingly able to access the basic elements of sound digital infrastructure. They also have digital analytical and information tools, such as Learning Management Systems that helps them to manage their teaching, communicate course content to their classes, track students' progress, communicate with individual students and conduct assessment (Ifenthaler, 2012[40]).

The ability of HEIs to make use of that infrastructure in a shift to digitalised delivery is likely to depend on their overall leadership on digital education issues, as well as the digital competence of staff and students. In higher education systems, the concept of digital maturity is often used to-denote a measure of the capacity of an institution to adopt and manage digital approaches across all its activities and functions. (Đurek, Kadoic and Begičević Ređep, 2018[41]). The level of digital maturity of an institution depends on the choices made by the leadership of an institution and by the capabilities of the various faculties and departments to make the HEI commit to the digital maturity programme (Marshall, 2018[42]).

Furthermore, even at HEI level, the abilities of the top-level institution leadership to mandate the measures needed for digital maturity may be limited (Marshall, 2018[42]). In larger institutions, some faculties and departments are likely to be large entities that exercise considerable autonomy in their own right; they control large budgets and an extensive staff and have considerable discretion in their use of digital resources. As a result, in larger HEIs, digital maturity may differ widely between the constituent parts of an institution. Finally, some evidence indicates that the extent of digital capacity among teaching staff in higher education may vary within an institution depending on the teachers' field of study (for example (Cabero-Almenara et al., 2021[43])), resulting in differences in capacity between the faculties or other components of the HEI.

Students and actors across the wider learning environment need capacity to engage successfully with digital education

Students and (in some cases) parents need support to build capacity for successful digital learning

Efforts to build capacity for the adoption of digital education technologies should also be guided by an assessment of the degree to which learners or their parents (in the case of younger students) are ready, willing, and able to integrate technology into the learning process (Ganimian, Vegas and Hess, 2020, p. 23[44]). This can help authorities to detect challenges, resistance or inequities that may arise during the implementation of reforms due to a lack of preparedness in parts of the system (Ganimian, Vegas and Hess, 2020, p. 23[44]).

To make the most of digital technologies for learning, students must be equipped with a range of foundational skills, other than digital competence. Strong literacy, numeracy, and problem-solving skills in technology-rich environments support students' ability to progress from basic Internet use to more diverse and sophisticated applications (OECD, 2019[7]). Similarly, fostering students' socio-emotional skills can serve to promote safer and more responsible uses of digital devices (Burns and Gottschalk, 2019[45]). Students' cognitive and socio-emotional skills are thus determining the capacity to seize the benefits of digital technologies and address some of their risks. Low-skilled students are, for instance, more likely to use the Internet for recreational rather than instructional activities (van Deursen and van Dijk, 2014[46]; OECD, 2019[7]).

The share of 16-24 year-olds lacking basic skills (literacy, numeracy and problem solving in technology-rich environments) is lower than among adults aged 25-54 or aged 55-65, on average across OECD and EU countries with available data in the OECD Programme for the International Assessment of Adult Competencies (PIAAC) (OECD, 2019, p. 166[7]). At the same time, some countries display relatively similar shares of youth and prime-age adults lacking basic skills, suggesting that there is scope to enhance the equity and quality of their initial education systems. This is the case in Japan, Norway, New Zealand, Greece, the Czech Republic, the Slovak Republic, Australia and Denmark, where the difference was smaller than 2 percentage points (OECD, 2019, p. 167[7]).

Evidence from PISA (2018) also shows that significant challenges remain in building students' capacity to make the most of digital environments for learning. For instance, fewer than 1 in 4 students in Bulgaria and Greece displayed strong abilities to navigate digital environments in contrast to more than half of students in B-S-J-Z (China), Hong Kong (China), Korea, Singapore and Chinese Taipei, and around 40% of students in Finland, Ireland and the Netherlands (OECD, 2021[47]).[6] Strong navigation abilities were highly correlated with students' reading performance and effective reading strategies.

Parents also play an important role in facilitating and shaping school students' access to and use of digital resources at home. Parents' attitudes and practices, as well as their awareness of the opportunities and risks involved in the use of digital education technologies will affect whether and how they encourage their children to play educational or collaborative video games, support them in the use of digital devices for their homework or, for example, restrict their access to digital devices (OECD, 2019[48]). Parents can thereby help their children maximise the benefits they derive from the use of digital technologies, while minimising the associated risk of harm.

Evidence suggests that low-skilled parents are more likely to adopt restrictive mediation strategies, reducing their children's exposure to online risks but also the likelihood that they benefit from the opportunities of digital technologies. In contrast, confident and high-skilled parents tend to take more enabling approaches to their children's Internet use that support their emerging digital skills and interests in ways that are responsive to their needs and safety (Livingstone et al., 2017[49]). Given the important role of parents in promoting their children's safe and effective use of digital technologies, gaps in adults' digital literacy are particularly concerning. Around 12% of prime-age (25-54) adults in OECD countries participating in the Survey for Adults Skills (2013, 2015) lacked basic literacy, numeracy and problem-solving skills in technology-rich environments on average (OECD, 2019[7]). Data from European countries from Eurostat also underline this issue and points towards large cross-country inequalities in adult digital skills (Eurostat, 2022[50]).

Sub-central authorities need to build capacity in line with their responsibilities for digital education

The role of sub-central authorities (i.e. local authorities and, depending on the system, state-level or regional-level authorities) in digital education policy and practice varies significantly across countries. Particularly in more decentralised systems, local or intermediate level authorities can play an important role in supporting successful digital education. Sub-central authorities may hold responsibility, for example, for allocating capital expenditure to schools and for authorising or taking decisions on the procurement of digital education technologies (OECD, 2017, p. 253[51]). In 2019, sub-central authorities in 20 of 27 OECD countries and economies with available data were involved in the allocation of capital funding to public primary schools (regional or provincial authorities in 11 countries and local authorities in 19 countries). At the lower secondary level, sub-central authorities in 19 of 26 OECD countries were involved in the process (OECD, 2021[52]).

Local authorities in some education systems also have significant responsibility for implementing education policies or supporting the digitalisation in schools directly, for example by managing local advisory or school improvement support services (Vincent-Lancrin, Cobo Romaní and Reimers, 2022[53]). Comparative data are lacking on the involvement of sub-central authorities in the acquisition, management and use of digital education technologies and their capacity to fulfil these specific responsibilities. Nevertheless, sufficient capacity of sub-central authorities to effectively carry out their responsibilities is known to be an important condition for the effective implementation of policies in the context of multi-level governance (OECD, 2017[51]), and the digital transformation of schools is no exception.

Promising approaches for building capacity to use technology effectively for teaching and learning

Pay more attention to preparing educators and other staff for the effective use of digital education technology

Further integrate capacity building for the effective use of digital education technology into initial training for educators

At the school level, several OECD countries have updated their initial teacher education programmes in order to ensure that they provide prospective teachers with a solid foundation to make effective use of digital education technologies. This included the introduction of compulsory or voluntary courses in ITE, national accreditation standards or certifications, or placing greater emphasis on digital skills across the ITE curriculum:

- The **Norwegian** Government established the Centre for Professional Learning in Teacher Education (ProTed) as a partnership between the universities in Oslo and Tromso. In addition to running innovative teacher preparation programmes, ProTed conducts research projects and disseminates research findings on what constitutes excellent teacher education. One of the Centre's five focus areas is "teacher education for the digital future" and innovating the training of teacher educators. As part of these activities, the Centre fosters collaborations between universities and schools and is leading teacher educators' collaborative work on revising the ITE programme guidelines to increase their coherence and links with practice (OECD, 2019, p. 36[54]).
- In **Denmark**, efforts to strengthen teachers' digital skills go back to at least the 1990s, with the introduction of the voluntary Pedagogical ICT Licence (*Pædagogisk IT-kørekort*). The Licence combined pedagogical knowledge of digital technologies and basic digital skills training and has become a European standard in the provision of digital skills to teachers. Implemented for in-service training at first, the Licence was later integrated as a voluntary element into the curriculum of student teachers in teacher education colleges (Rizza, 2011[55]).
- **Denmark** has also experimented with developing concurrent and linked capacity building initiatives for students and teachers together. In line with an increasing emphasis on students' role as active learners capable of creating with technology (Arstorp, 2021[56]), a new subject – technology comprehension (*teknologiforstaelse*) – was introduced in 46 pilot schools between 2018-2021. In conjunction, a multiple universities and teacher professional colleges collaborated to develop a corresponding ITE course for teachers. A 2021 evaluation found the teachers' ITE course to have strengthened teachers' content knowledge for the technology comprehension course and, to some extent, their pedagogical knowledge on the subject. The evaluation also provided recommendations for the programme's further improvement, including the establishment of fora for professional exchange with practicing teachers and allowing more time for reflections on the course content's interaction with other subjects (Danish Evaluation Institute, 2021[57]).
- **France** strengthened the role of digital competencies in its teacher education system to put a greater emphasis on digital skills in students' curricula. In 2019/20, France introduced new courses related to digital technologies in teacher training at the upper secondary level and a new Reference Framework of Digital Competences (*Cadre de référence des compétences numériques*), covering primary, secondary and higher education with end-of-cycle assessments to ensure their ability to foster students' digital skills, new teachers obtain a corresponding certification. In addition, a new programme aims to develop specialist ICT teachers and a mandatory three-day training course for all lower secondary teachers was introduced in 2016 (OECD, 2020, p. 22[58]).

At higher education level, because of the greater dispersal of autonomy throughout the system, governments do not play as strong a role in the initial training of academic staff, and there are few formal system-level teaching qualifications for staff at this level. However, governments in some countries are aiming to stimulate the uptake of professional teaching qualifications for both new and existing academic staff, which can also provide opportunities to train staff on digital pedagogy. For instance:

- In **the Netherlands**, the government encouraged universities to develop a teaching qualification for higher education educators, and all of Netherland's research universities currently use and mutually recognise the University Teaching Qualification (Basiskwalificatie Onderwijs – BKO), first created in 2008 (VSNU, 2018[59]). The training programme allows lecturers to develop and document their teaching practice with support from a senior lecturer or educationalist, with certification based on evaluation of a portfolio submitted at the end of the teaching development phase. In a 2018 review of the university teaching qualifications, Universities Netherlands advised its member institutions to pay extra attention to "ICT and blended learning", including both "specific skills in dealing with new applications" and "how digitalisation makes education even more teamwork, with instructors being supported by specialists in areas such as online didactics instructional design, video, and social media" (VSNU, 2018[59]). In other higher education systems, such as Hungary, there are plans for a centrally developed and common digital competence training for the higher education system, the scope and depth of which remain to be determined.
- In **New Zealand**, a range of national certificates and diplomas in tertiary teaching have been introduced, aimed at both tertiary vocational and higher education teachers, with related education programmes offered by more than 20 providers. The certificates and diplomas can be achieved at several levels of New Zealand's national qualification framework (level 4 to level 8). The related education programmes often include a focus on technology-enhanced learning (New Zealand Qualifications Authority, n.d.[60]).
- In **Korea**, the Ewha Womans University offers an example of an ITE institution embedding innovative uses of technology and interdisciplinary research in the development of ITE programmes. One example of this approach is the university's integration of flipped learning techniques based on the intensive use of technology and Internet-based resources. The pedagogical approach seeks to improve the personalisation of ITE instruction and ensure that there is more time in the classroom for meaningful face-to-face interactions while also familiarising candidates with digital pedagogical methods. Initial research and development funded by the Ministry of Education was carried out to investigate how technology can support flipped learning techniques using experimental piloting. Once the technique's effectiveness had been established, it was introduced formally as a core method in ten ITE courses. The technology component of flipped learning was supported by the work of other institutions such as the Research Institute of Distance Education. Ewha Womans University has received the highest evaluation rating by the Korean Educational Development Institute in all four national evaluations of ITE undertaken between 1998 and 2015 (OECD, 2019[61])
- In **France,** training for assistant professors is compulsory when they take up their first job. Candidates are provided 50 hours of leave to attend mandatory pedagogical courses. Among other aspects, these courses include training on the delivery of online and hybrid teaching. Whilst each institution offers its own training courses with its pedagogical support service, the Ministry of Higher Education and Research runs a MOOC to train higher education educators ("Se former pour enseigner dans le supérieur") (France Université numérique, n.d.[62]).

Provide opportunities for professional learning on the use of digital education technology throughout the working life of educators

Ensure that educators have access to relevant and impactful opportunities for continuing professional learning

While teachers' initial education is critical to ensure that new school teachers are prepared for their work, continuing professional learning (CPL) is vital to broaden and deepen teachers' knowledge, to help them keep up with new research, tools and practices and to respond to their students' changing needs (Boeskens, Nusche and Yurita, 2020[8]). As discussed earlier in this chapter, international surveys suggest that teachers' training is an important condition for the effective integration of digital technologies in the classroom (Gil-Flores, Rodríguez-Santero and Torres-Gordillo, 2017[15]; Fraillon et al., 2014[10]).

CPL is also increasingly recognised as vital for the development of digital capacity within higher education systems, although CPL may be organised in more diverse ways, compared to schools. Professional development programmes for digitally enhanced instruction may be organised and implemented across the entire higher education sector, developed and implemented by individual HEIs, or by some combination of central and local capacity building. The precise mix of these approaches will vary according to national policy making traditions and existing institutional capabilities – for example, systems with a large number of small institutions that have modest capabilities for digital learning will likely want to invest in building system-wide sharing capabilities, and these may take a variety of legal and administrative forms, such as a co-operative association, private charitable organisations to which HEIs subscribe, or university-based centres that serve as a service provider for the entire higher education sector.

Effective forms of CPL can help teachers improve their practice throughout their career (Kraft and Papay, 2014[63]; OECD, 2018[64]). Some countries have thus taken steps to strengthen CPL for digital skills and provide teachers with the necessary resources to engage in professional development:

- With the 2015 Good School reform (*La Buona Scuola*), **Italy** has emphasised school autonomy and teachers' responsibility for their professional learning as key levers for educational improvement while providing targeted support for strengthening digital competencies. The reform made teachers' participation in in-service training mandatory and provided EUR 1.5 billion for training in areas of system skills (school autonomy, evaluation and innovative teaching), "21st century skills" (including digital skills) and skills for inclusive education. The reform left teachers with significant autonomy to tailor their professional learning to their needs, providing them with EUR 500 per year via a "Teachers' Card" to participate in training activities, purchase resources (books, conference tickets, etc.) and offering matching processes to align training offers with training demands using a digital platform (OECD, 2017[65]). An evaluation focused on teachers' digital skills concluded that the training offer was in line with European Parliament's resolution "Learning EU at school" and promises to provide relevant and effective professional development opportunities (Rosa and Taddeo, 2021[66]).
- Teaching staff in the **United States** often access CPL through micro-credentials programmes specifically designed for teachers, which often can be counted as satisfying the CPL requirements of teachers. The Digital Promise collaborative micro-credentials initiative "Digital Promise" offers over 450 research-backed micro-credentials relevant to early childhood education, school education, higher education and adult learning. Educators who participate can earn continuing education credits with their employing state or district. The offer includes a range of education programmes leading to credentials in areas such as assistive technology, digital literacy, digital citizenship, technology planning and virtual reality (Digital Promise, n.d.[67]).

Although the literature specifically concerned with CPL on the use of digital technologies is limited, over recent decades a wealth of new evidence has caused a paradigmatic shift in the way school systems conceive of effective forms of professional learning more generally (Boeskens, Nusche and Yurita, 2020[8]).

Traditionally, professional development has often taken the form of single or short series of externally provided learning courses. Evaluations frequently found that these courses fail to lead to meaningful improvements in teaching quality or student outcomes (Glazerman et al., 2010[68]; Jacob and Lefgren, 2004[69]; Garet et al., 2016[70]; Garet et al., 2008[71]). Meta-reviews of randomised controlled trials have echoed concerns about the effectiveness of traditionally delivered professional development (Kennedy, 2019[72]; Kennedy, 2016[73]).

New forms of professional learning tend to stress features such as collaboration (Opfer, 2016[74]), the use of external expertise and individualised instructional coaching (Kraft and Blazar, 2017[75]; Blazar and Kraft, 2015[76]) or matching effective teachers with less effective ones (Papay et al., 2016[77]). In a systematic review of the empirical literature, Darling-Hammond et al. (Darling-Hammond, Hyler and Gardner, 2017[78]) find that professional development with demonstrated benefits for student learning generally displays one or more of the following characteristics:

1. It is content-focused.
2. It incorporates active learning utilising adult learning theory.
3. It supports collaboration, typically in job-embedded contexts.
4. It uses models and modelling of effective practice.
5. It provides coaching and expert support.
6. It offers opportunities for feedback and reflection.
7. It is of sustained duration.

At the same time, none of these design features can guarantee effectiveness in and of themselves (Timperley et al., 2007[79]). Many interventions with popular design features have no effect on student achievement, or smaller effects than cost-free interventions that encouraged teachers to engage in informal peer support (Papay et al., 2016[77]). In general, what matters for effective professional learning appears to be that its contents are well aligned with the intended learning goals and that they include a variety of activities to reinforce messages and allow teachers to test and interrogate their practice from multiple angles (Timperley et al., 2007[79]).

Create organisations that focus on professional learning, including digital capacity building

Knowledge centres and professional learning organisations can provide highly visible and specialised focal points for educators wishing to build capacity in digital teaching and learning. Such organisations are relevant to capacity building efforts at all levels of education. Examples of initiatives from across the OECD include:

- In **Denmark**, the Knowledge Centres for IT in Teaching promotes the use of advanced digital technology in VET, offering professional development courses for teachers. The centre has also established a network of pedagogical staff and a network of leaders to facilitate the exchange of ideas, practical and technical knowledge and to address common challenges. In addition, two knowledge centres for automation and robot technology each work with more than a dozen VET schools to support teachers to operate VR equipment and robots and incorporate them into their teaching practice (OECD, 2021[16]).
- In **Spain**, the Centre for Innovation in VET in Aragón is a professional training centre for VET teachers and acts as a hub to promote innovation across VET providers, universities and industry. The centre provides advanced technology and equipment for VET teachers in the logistics, transport and manufacturing sectors (such as VR vehicle simulators and an automated logistics chain reproducing the processes of a manufacturing company). The centre offers a wide variety of professional

development activities on the use of these technologies as well as learner-centred methodologies for teaching in VET (OECD, 2021[16]).

- Within higher education systems, national programmes may be used to supplement the in-house programmes. For instance, in the **United Kingdom**, the national higher education teaching and learning academy, Advance HE, runs programmes, conferences and events for educators to enhance their teaching (Advance HE, 2021[80]). There are similar centres outside of Europe as well, such as in **New Zealand**'s National Centre for Tertiary Teaching Excellence (*Ako Aotearoa*). These centres provide an effective means by which to scale and co-ordinate support for digital transformation in teaching. In **Ireland**, for example, the National Forum for the Enhancement of Teaching and Learning in Higher Education has made *Teaching and Learning in a Digital World* a priority area of focus.

Focal points for professional learning related to digital education can also be created at the level of individual education institutions, or as part of inter-institutional co-operative efforts. For example, many HEIs, in Europe and in other OECD jurisdictions, have set up institution-based professional development centres (Parsons et al., 2012[81]; Chalmers and Gardiner, 2015[82]).[7] These programmes aim to support higher education educators to improve and professionalise their teaching practice, including in preparing for and adapting to technology-enhanced approaches. HEIs in some OECD countries that are on the forefront of digitally enhancing learning have established executive leadership posts for digital transformation and central units for digital transformation (Keune, 2022[83]), (Office of the Provost, nd[84]), and implemented communities of practice and training to support the use of learning analytics among their educators. While evidence of the longer-term effectiveness of such programmes is still limited, university teacher development programmes more generally have been found to have a positive impact on teachers and students (Chalmers and Gardiner, 2015[82]).

As the adoption of digital approaches to higher education teaching becomes more widespread, there is an important role for professional development centres to help teachers become more proficient in the use of technologies (Rienties, Brouwer and Lygo-Baker, 2013[85]). The programmes co-ordinated by these centres should target teachers who are tentative and unconfident in using technology in their teaching; they need to minimise the risk of being overly focused on early and enthusiastic adopters (Tømte et al., 2019[86]).

Inter-institutional partnerships, associations or co-operatives as well as structured professional exchanges with researchers and EdTech firms can also support professionals to make informed choices when selecting digital education technologies and integrating them into their teaching (see Chapter 3). Support teams or teacher networks responsible for curating digital resources and tools as well as central or community-based databases of software can all support this process. There are several examples in Europe of platforms offering professional learning communities for teachers to exchange digital materials and practices or engage in networked e-learning:

- KlasCement is a resource network run by the Ministry of Education and Training in the **Flemish Community of Belgium**, which allows teaching resources and professional development materials to be shared with and among teachers. A team of moderators from the ministry manages the network, although there is no systematic quality control of the resources shared on the platform. During the COVID-19 pandemic, KlasCement curated teaching and learning resources from the network to support teachers in adapting to remote teaching and organised webinars with pedagogical experts on topics such as the use of digital tools for distance education. In early 2020, the platform had more than 250 000 active members (OECD, 2021, p. 13[87]; Minea-Pic, 2020[13]).
- The European Commission's **School Education Gateway** and **eTwinning** platforms provide education professionals with opportunities to communicate, share practices, create collaborative projects using digital technologies, access and share resources. In 2022, the two platforms will be merged into the European School Education Platform (European Union, 2022[88]; Kools and Stoll, 2016, p. 43[89]; European Commission, 2022[90]).

Encourage or directly support the creation of peer learning opportunities, including communities of practice.

Communities of practice can be particularly powerful ways to promote teachers' professional growth (Gil-Flores, Rodríguez-Santero and Torres-Gordillo, 2017[15]). Professional learning communities can be highly effective means to promote incremental improvements in teachers' instructional practices and foster innovative teaching (Kools and Stoll, 2016[89]; Stoll et al., 2006[91]).

- **Australia's** Digital Technologies in Focus project connects schools with curriculum officers who support clusters of schools and lead workshops for school leaders and teachers to foster collaboration on the implementation of the digital technologies curriculum (OECD, 2020[12]). This is complemented by free online MOOCs and professional learning events developed by the Computer Science Education Research Group at the University of Adelaide. The Digital Technologies Hub developed for the Australian Department of Education, is another platform offering learning resources related to the implementation of the digital technologies curriculum for teachers, students, parents and school leaders (OECD, 2020[12]).
- In **Germany**, the Digital Pact for Schools (*DigitalPakt Schule*) – a joint initiative between the federal and Länder level – aims to improve general digital education at all school levels (primary to upper secondary and VET schools). As part of a suite of measures, the pact supports investments in digital infrastructure, the development of digital content and curricula, and strengthening teachers' digital competencies through professional learning (OECD, 2018, p. 228[92]; OECD, 2021, p. 181[93]). A central website provides an overview of professional learning opportunities available online and in all 16 states (Deutscher Bildungsserver, 2022[94]). In addition to more traditional one-off training formats and online courses, previous evaluations of small scale interventions focused on groups of teachers developing digitally supported learner-centred practices for their school context (Bremer and Antony, 2017[95]) and using intensive coaching and communities of practice (Dinse de Salas, 2019[96]) have shown promising effects on teachers' self-efficacy and their integration of digital technologies in the classroom.
- In the **French Community of Belgium**, the Foundation for Education's initiative (*Entr'Apprendre*) organises short internships (two to four days) for VET teachers to update their knowledge of new technologies used in the workplace (OECD, 2021[16]).
- In the **European Union**, the Digital Education Hub[8] was set up as a cross-sectoral community of practice in June 2022. It brings together stakeholders interested in digital education and training and working in all sectors and levels (pre-primary, primary, secondary, vocational, higher and adult education and training). The aim of the Hub is to foster collaboration and exchanges, to promote peer learning and to upscale innovative solutions in digital education.

Supporting the adoption of assistive technologies to provide support for students with special education needs

A lack of training on the use of assistive technologies can compromise educators' ability to support students with SEN. At the school level, several empirical studies have shown that targeted professional learning can improve teachers' knowledge and sense of efficacy in using assistive technologies in schools, although as of now, there is little evidence on the longer-term effects of such interventions (Atanga et al., 2020[27]). For example:

- Student teachers in a mid-sized southern university in the **United States** were offered additional learning opportunities on the use of assistive technologies for students with visual impairments, either as part of class instruction or to earn extra credit. The training exposed them to computer software, such as ZoomText magnification and screen readers as well as iPad applications for digital audio media, such as Learning Ally, which provides audiobooks and other resources for those with dyslexia and other learning differences. Pre- and post-tests suggest that the training improved participants' knowledge of relevant assistive technology and their efficacy, although the impact on future teaching practices could not be observed (Jones et al., 2019[97]). Previous studies of similar interventions had found comparable results (Poel, Wood and Schmidt, 2013[98]).

- In the **United Kingdom**, the Department for Education ran an Assistive Technology Training Pilot programme for 79 schools from January 2022 to March 2022. The intention of the training was to upskill school staff in identifying and implementing appropriate assistive technology for pupils with SEN in mainstream schools. The training received led to increased awareness among participating staff of different types of assistive technology applications and many participating staff reported being encouraged by the ease of use of the technologies. Participants also showed an increase in confidence ratings to use different types of assistive technology, with more than 40% reporting high levels of confidence for some forms of technology application after the training, compared to 10% or less beforehand. However, participants also highlighted the likely initial impact on their workload, and although they could envisage that the technologies may eventually reduce their workload, this was not observed during the pilot period (Department for Education, 2022[99]).
- Also in the **United Kingdom**, the UK NREN Jisc offers training programmes on needs assessment and decision making for higher education staff with regard to assistive technologies for students. Jisc also co-ordinates an Assistive Technology network, which acts as a community of practice for all further and higher education staff with an interest in incorporating assistive technology in their practice (Jisc, n.d.[100]).

Digital technologies have also created greater opportunities for HEIs to provide higher education to students with SEN. A survey of the literature on supporting those with physical impairments and learning disabilities in higher education (Bong and Chen, 2021[31]) found that training of staff in the HEI is a key to moving beyond mere physical access. Training needs to cover matters such as accessibility standards (such as web content accessibility guidelines, privacy and information standards), and knowledge and experience of assistive technology devices. In particular, there is a need for programmes to be structured in ways that are flexible and that keep learners motivated. HEI staff involved in teaching or supporting those with special education needs should be trained in universal design for learning (UDL) which provides a guide to structuring teaching in flexible ways to accommodate the learner's special needs. Yet, while UDL is a proven, research-based method, it carries a high resource cost for HEIs. So governments can provide or encourage the provision of training for HEI staff in managing delivery to higher education learners with SEN, but they should also ensure that their per student funding formulae provide appropriate additional resourcing for HEIs with a distinct coefficient taking account of students with SEN.

Support education institutions to build a strong culture of digital education

The importance of cultivating schools as learning organisations built on an active professional exchange of practices has been stressed in the context of building digital competencies and effectively implementing digital technologies (Krumsvik, 2008[101]). Collaborative forms of professional learning are also an effective means to help teachers move from the mastery of technical skills to finding ways of tailoring the use of technology to their subjects' specific contents and instructional activities (OECD, 2020[35]). In TALIS 2018, a culture of professional collaboration in schools has been associated with a more frequent use of ICT for instruction (OECD, 2022[28]). Nevertheless, among 15-year-old students in PISA 2018, only 36% across the OECD and 34% across the EU attended a school that had a programme to promote collaboration amongst teachers on the use of digital devices (OECD, 2020[36]; OECD, 2020[9]).

Creating a school culture that allows for teachers' professional growth, that stimulates peer observation, constructive feedback and mentoring or coaching structures requires skilled pedagogical leadership at the school level (OECD, 2018[64]). School leadership teams therefore play a central role in preparing teachers for the successful integration of digital education technologies. They are critical to ensure that teachers remain motivated to engage in professional growth, to appraise teachers and link their individual learning with the school's overall priorities and strategies for the adoption of digital technologies. School level decisions (e.g. on the management of staff time) also shape teachers' opportunities to engage in collaborative practices and other forms of peer learning that are critical to build school level capacity for the successful adoption of education technology (Boeskens, Nusche and Yurita, 2020[8]).

While fulfilling these basic infrastructural needs is a prerequisite for the delivery of high-quality digital education, infrastructure alone is not sufficient. In order to exploit the potential of digital education technologies, education institutions need to be prepared and supported. This requires strengthening their digital capacity and their digital culture, i.e. "the extent to which culture, policies, infrastructure, and digital competence of students and staff support the effective integration of technology in teaching and learning practices" (Castaño Muñoz, Pokropek and Weikert García, 2022[6]; Costa, Castaño-Muñoz and Kampylis, 2021[5]).

Explore the potential benefits of providing central guidance for institutions

Even in contexts where education institutions enjoy a high degree of autonomy over the use of digital education technologies, central authorities can offer vital support, by giving them access to tools developed at the system level or by offering guidance on how to use digital devices effectively and safely in the classroom. Even higher education institutions, which usually enjoy vast pedagogical freedoms, can benefit from these central supports, especially in the case of smaller institutions or institutions with less resources to build their own capacity. Central authorities may formulate such guidance themselves or encourage and support actors at the local or school levels to develop them. In 2018, 62% of 15-year-old students in OECD countries attended a school with a general written statements about the use of digital devices, but only 46% had one that specifically addressed their use for pedagogical purposes (OECD, 2020[36]; OECD, 2020[9]).

Adapting curricula at different education levels to recognise the use of digital education technologies can be another means to support their integration into teaching practices (see Chapter 3). Likewise, some education systems have developed central libraries offering digital education materials to education institutions and educators or video libraries with examples of successful ways to integrate digital technologies in teaching:

- During school closures caused by the COVID-19 pandemic, the government of **France** facilitated access to 17 banks of digital education resources for school (*Banque de Ressources Numériques pour l'Ecole*, BRNE) to help teachers and schools ensure pedagogical continuity. These banks of resources were developed by publishers and EdTech companies prior to the COVID-19 crisis based on a public tender. BRNEs provide teachers with learning activities for their pupils as well as the means to modify or create their own digital learning materials. The banks of resources are portals that provide access to thousands of pages of content, tools for creation, services for dissemination and interaction between teachers and students (discovery, training, revision, learning and assessment activities). Contents are fully aligned with the French national curriculum in all disciplines and grades and tagged accordingly to make them easily accessible. Throughout their deployment, the BRNEs benefitted from extensive support from the French academies (regional sub-divisions) in the form of teacher training and the dissemination of information on teaching methods. The procurement phase allowed the Ministry to develop strong relationships with the contractors, who developed a better understanding and competency around the ministry requirements. According to the BRNE contractors, the number of new registrations increased 5 to 15-fold during the COVID-19 pandemic and several hundred thousand teachers used learning management systems (*espaces numériques de travail*) where the BRNE are deployed (Thillay, Jean and Vidal, 2020[102]).
- Also in **France**, there have been efforts to provide open education resources for hybrid courses. Government funding is provided for this purpose and the National agency for research is responsible for monitoring content. The FUN RESSOURCES platform has encouraged education institutions to

share their learning material, resulting in 32 000 uploads since the creation of the platform (France Université Numérique, n.d.[103]).

Invest in the capacity of school leadership

Pedagogical leadership plays a key role in driving and sustaining school improvement processes (Pont, Nusche and Moorman, 2008[104]). Ensuring that school leaders are motivated and enabled to lead the digital transformation of their schools is vital to achieve meaningful change in the classroom. School leaders represent an important interface between public authorities and the staff working in schools and play a critical role in promoting and sustaining technology-enhanced pedagogical innovations and in creating the conditions to strengthen teachers' capacity for digital education (e.g. through systematic collaboration and communities of practice) (Paniagua and Istance, 2018[105]). Public authorities should therefore consider targeting capacity investments specifically at this group.

Assessing the degree to which school leaders, educators, and learners are ready, willing, and able to integrate technology into the learning process is an important step informing the implementation of digitally enhanced education in schools. Listening to and evaluating the concerns of stakeholders can also flag challenges that could prevent the take-up of technologies and lead to cynicism or resistance to reforms. It can also yield important insights on the types of support that schools and teachers need and should inform interventions designed to strengthen their capacity, including the provision of adequate training (Ganimian, Vegas and Hess, 2020, p. 23[44]).

Some systems have sought to strengthen the digital capacity of their schools by investing directly in the professional development of school leaders, although only one-third of European education systems explicitly stated this goal as part of their strategic objectives in 2019/18 (European Commission/EACEA/Eurydice, 2019, p. 95[106]). For instance, the **Slovenian** 2016-20 strategy for the implementation of digital education included strengthening e-competences among all actors of the education system as one of six main objectives. To attain this objective, the ministry sought to offer counselling and training to school leaders related to digital technologies, strengthen professional e-communities, the active exchange of good practice and peer learning (European Commission/EACEA/Eurydice, 2019, p. 94[106]). Slovenia's middle leadership programme, managed by the National School for Leadership in Education, brings together leadership staff from different types of schools to take part in structured school visits followed by reflections and training in order to promote the sharing of good practices (OECD, 2021, p. 89[93]). Annual evaluations rate the programme highly and provide evidence of successfully implemented changes in schools. One of the main challenges reported by participants is the need to develop incentive mechanisms to reward participation and performance in the programme (OECD, 2019, p. 494[107]).

Support education institutions' efforts for self-evaluation of their digital capacity and their development of digital education strategies

Evaluation practices at the system- and institution-levels can play an important role in improving the use of digital education technologies in education institutions. The relationship between digital technologies and evaluation practices is complex. On the one hand, digital technologies can facilitate the implementation of self-evaluations in schools (e.g. principals might use online surveys to solicit feedback from educators, students and other stakeholders). On the other hand, educators' practices regarding the use of digital technologies can be subject of internal and external evaluations and may be included in system-level guidelines for evaluations (OECD, 2019, p. 33[48]).

Several countries have adapted their evaluation frameworks to account for the use of digital education technologies in education institutions. At the school level, in 2018/2019, 10 EU countries had included evaluation of digital education specifically in their external school evaluation frameworks, with varying evaluation methods and data sources (e.g. surveys, classroom observation) (European

Commission/EACEA/Eurydice, 2019[106]). Others encourage schools to emphasise the assessment of digital capacity in their self-evaluation practices and support them in the process (for an in-depth discussion, see Chapter 9).

Enabling education institutions to take stock of their strengths and weaknesses when it comes to the use of digital education technologies is an important condition for their development of digital education strategies and improvement plans (European Commission, 2020[1]). Self-evaluation tools can provide a useful framework for education institutions to take stock of their current position and structure conversations around strengths and areas for improvement. Examples include:

- The Self-reflection on Effective Learning by Fostering the use of Innovative Educational technologies tool (SELFIE) is an online tool launched by the **European Commission** in 2018 to assist schools in evaluating their digital capacity. The tool uses a questionnaire to gather views of the whole-school community – school leaders, teachers and students – and generates an interactive online report that provides aggregated data on strengths and weaknesses in the schools' use of digital technologies for teaching and learning. SELFIE is available for schools at the primary to post-secondary non-tertiary levels and is based in the Digitally-Competent Educational Organisations framework DigCompOrg (Kampylis, Punie and Devine, 2015[108]). It covers eight areas emerging from the literature on conditions for an effective use of digital education technologies: leadership, collaboration and networking, infrastructure and equipment, continuing professional development, pedagogy (support and resources), pedagogy (implementation in the classroom), assessment practices, and student digital competence (Castaño Muñoz, Pokropek and Weikert García, 2022[6]; Costa, Castaño-Muñoz and Kampylis, 2021[5]). SELFIE was expanded in October 2021 with a module on work-based learning (SELFIE WBL) to further support the VET sector. In addition to self-assessment of the digital capacity of schools, SELFIE for teachers provides individual educators with an opportunity to assess their digital competences and identify further learning needs.
- A similar strategic reflection tool for higher education institutions, entitled DIGI-HE, and which will be built on SELFIE and the DigCompOrg framework, is currently in development (Ehlers and Bonaudo, 2020[109]). The "Digital Transformation and Capability" element of the HEInnovate self-assessment tool can also support higher education institutions wishing to reflect on their current digital capacities (European Commission, 2022[110]).
- **Estonia** has developed a national tool, the Digital Mirror (*DigiPeegel*), for schools to measure the digital competences of their teachers and students, to assess their digital maturity and to develop an improvement plan (OECD, 2021, p. 92[93]). Over 400 general education schools had undergone the self-evaluation process between 2016 and 2019 (OECD, 2020, p. 17[111]). Evaluations of the tool's implementation were mixed and it has not been in used beyond 2019. Although some school leaders saw the process as a useful exercise to take stock of their schools' digital capacity, other leaders and teachers reportedly did not see the benefit of undergoing the exercise besides the extrinsic incentive to become eligible for public investments in digital infrastructure. Some also expressed uncertainty about the use of the evaluation's results or felt like the Digital Mirror duplicated existing surveys and assessments or was not well aligned with the schools' work on their development plans (Tammets et al., 2019[112]).

Monitor and address equity issues related to digital capacity in schools

More equitable digital education also requires bridging remaining divides in schools' digital capacity. Countries across the OECD need to devote further efforts in identifying the existence of equity gaps in access to schools with high digital capacity, as well as the nature (e.g. geographic, socio-economic, school size-related) of such gaps. Such inequalities can stem from structural policies (e.g. due to the difficulty of some education systems in attracting, developing and retaining qualified teachers or staff in the most disadvantaged schools) or may be the result of school or local-level factors or resource management decisions. Better mapping and identifying the factors that drive gaps in schools' digital capacity is therefore essential.

Countries can also envision the development of funding schemes that account for the characteristics of schools in the allocation of resources for digital capacity building. Often, countries have relied on a mix of approaches to compensate schools for general additional needs, including i) the provision of additional resources as part of regular funding allocation to schools and ii) targeted programmes/grants (OECD, 2021[113]). While targeted programmes can allow better steering for equitable resource allocation, they can also translate into inefficiency and a lack of predictability of resource allocations. In this respect, striking a balance between regular and targeted funding appears desirable. Such approaches can also be considered for the design of funding schemes seeking to bridge equity gaps in digital capacity between schools.

- Since 2017, **France** has aimed to strengthen digital capacity in rural schools with the targeted programme Innovative Digital Schools and Rurality Programme (*Programme Écoles numériques innovantes et ruralité*). Initially endowed with EUR 20 million , and with another EUR 15 million added in 2020, the programme supported around 7 000 schools with digital equipment to promote learning, enrich relationships with families and reinforce the attractiveness of rural schools and territories (Ministère de l'Éducation Nationale et de la Jeunesse, 2018[114]). This programme complements previous efforts to build capacity in rural schools, for example by fostering collaboration and by regularly letting teachers visit rural schools to promoting the use of educational materials and digital equipment in the classroom (*Équipe mobile académique de liaison et d'animation*, EMALA) (Echazarra and Radinger, 2019[115]).

Higher education

Supporting institutions in assessing and advancing their digital maturity

Focusing on organisational digital maturity not only supports the resilience of HEIs to manage future disruptions, but also creates opportunities for HEIs to enrich and transform teaching, learning and administration. Digital maturity can be enhanced by systematic planning, and commitment of resources to digital infrastructure and staff training (Đurek, Kadoic and Begičević Ređep, 2018[41]), (Marshall, 2012[116]).

Given their generally high levels of autonomy, leadership teams in HEIs will bear primary responsibility for development of their digital maturity. However, governments and public authorities have a role to play in steering HEIs to prioritise and plan for digital maturity. Self-reflection can be encouraged by the promotion of evidence-based toolboxes for HEIs to assess their current position such as the DigCompOrg framework (European Commission, 2015[117]).Governments can also stimulate an increased institutional focus on digital maturity through national level frameworks and strategies. For example, the Norwegian Digitalisation Strategy for the Higher Education Sector 2017-2021 placed requirements on higher education institutions to define related goals, as part of the central funding process (Regjeringen.no, 2017[118]).

Assessing digital maturity may expose shortcomings in an institution's capital resources. Advancing digital maturity will also require ongoing commitment of resources to upgrade relevant digital infrastructure. Managing that challenge at HEI level will depend on the country's approaches to capital funding and procurement. As discussed in Chapter 6, NRENS are increasingly providing higher education institutions with a range of digital services that can support advancement in digital maturity (Géant, 2020[119]; SURF, 2022[120]; JISC, 2022[121]). Beyond direct funding of digital infrastructure, governments can also stimulate institutions to invest in their own digital advancement through topping up or matching their financial commitments to specific projects (whether directly or through partnerships with private businesses). For example, **Ireland**'s Higher Education Strategic Infrastructure funding rounds are open for application to all higher education institutions and provide up to 50% of funding for strategic investment projects, including projects that maximise the use of digital technologies (Government of Ireland, 2019[122]).

Finally, given the increasingly competitive environments in which many higher education institutions operate, governments can highlight the competitive advantages that digital maturity can bring to organisations, such as greater satisfaction of staff and students with their experiences, greater efficiency in administrative processes and improved readiness to innovate and adopt new technologies (Boston Consulting Group, 2021[123]). Devising means to publicly highlight advancements or innovations that promote organisational digital maturity can also support this objective. Such mechanisms have already been successfully implemented by governments in many countries in the sphere of teaching and learning (OECD, 2021[124]), and through "digital innovation awards" provided by international commercial ranking bodies.

Supporting systematic survey-based student feedback to encourage high-quality teaching with digital education technologies

Students continuously make their own assessments of their teaching and learning experience. Such insights can help improve teaching quality, but only if they are collected and analysed in an appropriate way (Hénard and Roseweare, 2012[125]). Student feedback can help lift the effectiveness of course design and delivery, facilitate dialogue between an HEI and students, identify good practice, assess student satisfaction and contribute to staff development (Brennan and Williams, 2004[126]).

HEIs can obtain student feedback through surveys, course evaluations, "instant feedback" techniques (Hénard and Roseweare, 2012[125]), while digital technologies and video recording of classes also provide mechanisms to capture student feedback (Deeley, 2018[127]), (MacKay, 2019[128]). At an HEI level, the challenge is to harness feedback to enable systematic analysis that can contribute to the enhancement of quality across the HEI and to feed into the institution's strategy for teaching and learning.

At the system or national level, there is scope as well to use existing survey instruments, such as the **UK** National Student Survey or the **Danish** Learning Barometer, neither of which currently contain questions eliciting information about the effective – or ineffective – use of digital technologies in instruction. Alternatively, governments may choose to field a dedicated survey instrument focused on the digital learning environment as the **Irish** government did in 2019. The Irish National Digital Experience (INDEx) survey, conducted in 2019, asked students (and higher education teachers) about how much and what types of technology were used in their classes, how well the technology was deployed and how their experience could be improved (National Forum for the Enhancement of Teaching and Learning in Higher Education, 2020[129]). The results of the survey have been used by HEIs to modify their approaches – for instance, as a result of reviewing their students' responses in the INDEx survey, some HEIs purchased additional laptops for their laptop rental scheme, one HEI redesigned its Virtual Learning Environment (VLE) and some HEIs developed and disseminated guidance materials for students and educators (National Forum for the Enhancement of Teaching and Learning in Higher Education, 2021[130]). The survey results were also used by HEIs in developing their pandemic responses.

The Irish INDEx survey shares questions with a similar UK post-secondary education student and staff survey conducted annually by the British NREN JISC and also taken by a number of universities in Australia and New Zealand (JISC, 2020[131]); this allows for some cross-jurisdiction comparisons of students' digital experiences.

The value that the INDEx survey brought to Irish HEIs suggests that governments should encourage those who manage national student surveys to include a digital experience focus in their national student surveys or, if there is no national student survey, they should encourage HEIs to focus on the digital experience in their institutional surveys.

Prepare students and actors across the wider learning environment for digital education

Successfully implementing education policies and achieving tangible improvements in teaching and learning requires co-ordinated efforts and capacity building among many actors at multiple levels of the educational system (Viennet and Pont, 2017[132]). The form that capacity building efforts should take across the wider learning environment depends on an education system's governance arrangements (e.g. the degree of local and school autonomy) and will vary across levels of education (e.g. parents and local authorities are important mediators of digital policies the school level but not at the higher education level).

Build students' skills for digital education

Beyond general policies to enhance the quality and equity of education systems that can support students' skills overall, countries can rely on a range of strategies for building students' skills for digital education. OECD countries have thus relied on a combination of approaches by teaching new competencies from an early age, adapting school curricula to changing skills requirements, designing extracurricular activities focused on digital skills development, and enhancing teachers' digital competence. For instance, evidence from 22 education systems, which responded to the OECD 21st Century Children Policy Questionnaire, shows that many education systems put an emphasis on teaching both "hard" and "soft" digital skills including critical information, social and creative skills, as well as basic operational skills at the primary level and particularly more at the secondary level (Burns and Gottschalk, 2019[45]).

In this respect, the definition of digital competence has also been constantly evolving. The focus has progressively shifted towards developing a mix of skills, including understanding algorithms, critical application of digital technologies, collaborative problem solving using such technologies, media literacy, and resilience online. There has also been a trend, observed in some countries, to integrate digital skills transversally across the curriculum (for example as "computational thinking") rather than through stand-alone classes (OECD, 2019[7]). For instance, Australia, Chile, Estonia, Hungary, Ireland, Japan, the Netherlands, New Zealand, Scotland (United Kingdom) and Wales (United Kingdom) reported introducing digital technologies and skills as a cross cutting theme across multiple subjects or the entire curriculum (OECD, 2020[133]).

Support parents and caregivers as digital education facilitators

In addition to providing school-based support to students for their use of digital learning technologies through curriculum and digital skills training, home-based support for learners and support opportunities for parents should also be envisioned. This could take the form of monitoring student and family access to connectivity and devices at home to identify accessibility gaps; training parents and caregivers (e.g. using the school facilities for digital skills training of adults and caretakers in the community); providing digital solutions to help students and caregivers trouble-shoot whenever they face an issue with the digital education technology (e.g. hotlines and helpdesks). Building digital skills strategically across the life course through a system-wide approach can strengthen capacity among stakeholders beyond the classroom to support students' learning with digital education technologies:

- **Estonia** integrated a digital transformation programme in its lifelong learning strategy, with the aim of providing a digital focus in lifelong learning by i) incorporating a digital culture in the learning process, ii) supporting digital learning resources in schools, iii) accessing a modern digital learning infrastructure, iv) creating and implementing assessment models for digital competence and v) creating learning opportunities for adults to acquire digital competence (Estonian Ministry of Education and Research, 2014[134]) (see Chapter 2 for further examples of holistic system-wide approaches to digital skills).

Some countries have worked on the provision of guidelines to parents on the use of digital technologies for educational purposes.

- For instance, the Office of Educational Technology in the **United States** has prepared a Parent and Family Digital Learning Guide to support parents in helping their children thrive in digital education (US Office of Educational Technology, 2021[135]). The Guide was prepared to support all parents, starting with more foundational steps for those lacking the necessary skills and building upon for those who are more at ease with digital technologies.
- Through its Digital Education Territories (*Territoires Numériques Éducatifs*), **France** has created a regional structure for capacity building on digital education. Among other things, digital education territories offer resources and workshops to parents on topics related to the use of digital tools for learning and digital risks for children. They also provide opportunities for parents with more digital capital to certify as mentors and help other parents or students with the use of digital technologies (République française, n.d.[136]).

Ensuring that parents have the necessary digital competence to support their children's learning with digital technologies is critical to bridge inequities between students of different backgrounds.

- In the **United Kingdom**, the government funds free qualifications for adults lacking the essential digital skills needed for work and everyday life (UK Government, 2022[137]). Education and training providers carry out an initial skill level assessment in order to ensure eligibility and enrol individuals at an appropriate course level. Beyond government provision, local communities, libraries and associations also can also support the development of adults' and parents' digital skills. The United Kingdom's Good Things Foundation has co-designed free online learning resources to help individuals build their digital skills. It also ran the Future Digital Inclusion programme in partnership with the Department for Education to support the digital inclusion of the hardest to reach groups in society, focusing on learners with low skills and confidence (Good Things Foundation, 2021[138]).
- The City of Ghent (**Flemish Community of Belgium**) runs the Digitaal.Talent@Gent programme to support digital inclusion, by combining a range of interventions: lending hardware to schools and organisations, providing coding summer camps for students from socio-economically disadvantaged backgrounds, setting up digital banks where citizens can go for accessing digital devices, receiving training and support, etc. In addition, the programme provides supports to vulnerable families in introducing digital education games for young children and getting started on digital communication and media literacy (through lessons parents of primary children can attend in schools) (City of Ghent, 2022[139]).
- Across **Belgium**, **Bulgaria** and **Romania**, the ERASMUS+ funded project Digital Education Among Roma Minorities in Schools (DREAMS) fostered the social, civic and intercultural competences of Roma parents through digital education (All Digital, n.d.[140]). Roma parents from Belgium, Bulgaria and Romania were taught how to tell and edit digital personal narratives in collaboration with local schools. Through fostering digital skills among Roma parents, the project strengthened their bonds with school communities and provided them with a digital platform to share their stories.

Beyond the provision of such support programmes for building adults' and parents' digital skills, schools and local communities play an important role in ensuring that potential beneficiaries know about these programmes. In this respect, fostering stronger school-parent links can also be an important mediating factor to foster parental capacity for digital education (e.g. raising awareness on parental digital skills needed to support their child's education, sharing information about capacity building activities available in the local community).

Finally, governments and providers of digital skills training programmes also need to ensure that such programmes are delivered in a way that caters for potential constraints of beneficiaries and enables them to effectively participate and engage. Participation in adult learning remains a challenge across most EU and OECD countries, where an average of only two in five adults engage in education and training every year according to data from the OECD Survey of Adult Skills (PIAAC) (OECD, 2020[141]). Governments and providers of training programmes should thus address barriers preventing adults from engaging in training to raise their digital skills (e.g. through provision of training outside working hours, arranging childcare support during the training) and seek to raise the motivation to learn of those who are completely disengaged from learning by creating engaging and relevant training opportunities.

Build capacity among sub-central authorities with responsibility for digital education

When sub-central authorities have a key role in supporting digital education (e.g. through the acquisition of digital resources for education institutions or the provision of support to the latter), building their capacity is critical to ensure they can effectively deliver on their responsibility. Building capacity at the sub-central level should thus include a focus on resource management whenever the latter falls under the responsibility of sub-central authorities, as well as professional development programmes for staff in relation to digital education technologies. Such programmes could relate to the management of digital resources, quality assurance for digital education, financial planning for digital resources in education institutions, etc. Beyond professional development, encouraging collaboration and resource sharing can also be an effective way of building capacity among sub-central authorities with responsibilities for digital education (OECD, 2017[51]). Some countries maintain centrally co-ordinated networks of experts who can be dispatched to build capacity at the local and regional level:

- In **France**, a network of local digital advisors has supported local authorities in the implementation of digital education technologies since 2013. The advisors provide support on digital matters to the rectors of France's 30 education academies (or administrative districts), liaise with local authorities and companies, lead initiatives and facilitate networks around the uses of digital tools in education. The advisors also develop training programmes and mobilise knowledge for teachers to become more active in the use of digital tools for learning. Each academy has at least one digital education advisor, with most having less than 15, totalling several hundred advisors. In co-ordination with the ministry's Directorate for Digital Education, this strong network of skilled experts could be mobilised to prepare and oversee the transition to remote learning during the COVID-19 pandemic (Vincent-Lancrin, Cobo Romaní and Reimers, 2022[53]).

Key messages

The effective use of digital learning technologies requires sufficient capacity at all levels of the education system. As digital technologies increasingly permeate classrooms in OECD and EU countries, the capacity of educators to put these technologies to effective use is becoming a critical bottleneck in many education systems. The digital skills of educators vary strongly across countries but are consistently reported as one of the areas in which educators face the biggest training need. This chapter therefore highlights a range of policies aiming to build educators' capacity for digital education through initial training and continuing professional development. These include strengthening opportunities for peer learning as well as the creation of organisations providing teacher training in the area of digital skills and pedagogies. In this context, the chapter also points at the importance of specialised training to prepare teachers for the use of assistive technologies to support learners with SEN.

Education institutions play a critical role in encouraging and empowering educators to integrate digital technologies in their pedagogical practice. By creating a culture of professional learning and innovation, institution level policies can promote the take-up and more effective use of digital technologies. This chapter therefore presents policies that serve to build capacity at the institution level by strengthening instructional leadership, providing central guidance to education institutions and facilitating opportunities to benchmark and assess institutions' performance through self-evaluation or student feedback.

The effective digitalisation of education systems also requires the preparation of the wider learning environment. Students' digital skills are a prerequisite for their ability to navigate digital environments in a safe and productive way. Similarly, parents play a strong role in promoting their children's adequate use of digital technologies, especially at younger ages. The analysis in this chapter therefore emphasises the role of building students' and parents' capacity for digital education both to protect learners from harm and to allow them to seize the full potential of digital technologies. Lastly, the chapter considers the role sub-central authorities can play in supporting digital education and suggests some promising policies to build capacity for digital education at the local level.

References

Advance HE (2021), *Programme and events portfolio for 2021-22*, https://www.advance-he.ac.uk/programmes-events#Brochure. [80]

All Digital (n.d.), *Fostering the social, civic and intercultural competences of Roma parents through digital education • ALL DIGITAL*, https://all-digital.org/dreams-project-video/ (accessed on 1 June 2023). [140]

Arstorp, A. (2021), "25+ years of ICT in policy documents for teacher education in Norway and Denmark (1992 to 2020): A study of how digital technology is integrated into policy documents", *Education Inquiry*, Vol. 12/4, pp. 365-389, https://doi.org/10.1080/20004508.2021.1972594. [56]

Asselin, S. (2014), *Assistive technology in higher education in Information Resources Management Association USA Assistive technologies: concepts, methodologies, tools and applications*, DOI: 10.4018/978-1-4666-4422-9. [29]

Atanga, C. et al. (2020), "Teachers of students with learning disabilities: Assistive technology knowledge, perceptions, interests, and barriers", *Journal of Special Education Technology*, Vol. 35/4, pp. 236-248, https://doi.org/10.1177/0162643419864858. [27]

Basilotta-Gómez-Pablos, V. et al. (2022), "Teachers' digital competencies in higher education: a systematic literature review", *International Journal of Educational Technology in Higher Education*, Vol. 19/1, pp. 1-16, https://doi.org/10.1186/S41239-021-00312-8/FIGURES/6. [24]

Blazar, D. and M. Kraft (2015), "Exploring mechanisms of effective teacher coaching: A tale of two cohorts from a randomized experiment", *Educational Evaluation and Policy Analysis*, Vol. 37/4, pp. 542-566, https://doi.org/10.3102/0162373715579487. [76]

Boeskens, L., D. Nusche and M. Yurita (2020), "Policies to support teachers' continuing professional learning: A conceptual framework and mapping of OECD data", *OECD Education Working Papers*, No. 235, OECD Publishing, Paris, https://doi.org/10.1787/247b7c4d-en. [8]

Bong, W. and W. Chen (2021), *Increasing faculty's competence in digital accessibility for inclusive education: a systematic literature review*, DOI: 10.1080/13603116.2021.1937344. [31]

Boston Consulting Group (2021), *Investing in Education Technology*, https://www.bcg.com/fr-fr/publications/2021/investing-in-education-technology (accessed on 28 May 2022). [123]

Bremer, C. and I. Antony (2017), "Einsatz digitaler Medien für den lernerzentrierten Unterricht:Konzeption und Evaluation der Lehrerfortbildung "Lernkompetenz entwickeln, individuell fördern"", in Igel, C. (ed.), *Bildungsräume. Proceedings der 25. Jahrestagung der Gesellschaft für Medien in der Wissenschaft*, Waxmann, New York, https://doi.org/10.25656/01:16148. [95]

Brennan, J. and R. Williams (2004), *Collecting and using student feedback: A guide to good practice*, https://www.advance-he.ac.uk/knowledge-hub/collecting-and-using-student-feedback-guide-good-practice (Accessed 11 5 22). [126]

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. [45]

Cabero-Almenara, J. et al. (2021), *Digital competence of higher education professor according to DigCompEdu. Statistical research methods with ANOVA between fields of knowledge in different age ranges*, https://doi.org/10.1007/s10639-021-10476-5. [43]

Castaño Muñoz, J., A. Pokropek and L. Weikert García (2022), "For to all those who have, will more be given? Evidence from the adoption of the SELFIE tool for the digital capacity of schools in Spain", *British Journal of Educational Technology*, https://doi.org/10.1111/BJET.13222. [6]

Chalmers, D. and D. Gardiner (2015), "The measurement and impact of university teacher development programs", *Educar*, Vol. 51/1, pp. 53-80, https://doi.org/10.5565/rev/educar.655. [82]

City of Ghent (2022), *Alle Gentenaars digitaal mee | Stad Gent*, https://stad.gent/nl/samenleven-welzijn-gezondheid/welzijn/alle-gentenaars-digitaal-mee (accessed on 31 May 2022). [139]

Costa, P., J. Castaño-Muñoz and P. Kampylis (2021), "Capturing schools' digital capacity: Psychometric analyses of the SELFIE self-reflection tool", *Computers & Education*, Vol. 162, p. 104080, https://doi.org/10.1016/J.COMPEDU.2020.104080. [5]

Crawford, J. et al. (2020), "COVID-19: 20 Countries' Higher Education Intra-Period Digital Pedagogy Responses", *Journal of Applied Teaching and Learning*, https://journals.sfu.ca/jalt/index.php/jalt/article/view/191 (accessed on 17 April 2023). [37]

Danish Evaluation Institute (2021), *Evaluering af teknologiforståelse i uddannelse af laerere og øvrigt paedagogisk personale [Evaluation of technology understanding in the training of teachers and other pedagogical staff]*, https://emu.dk/sites/default/files/2022-01/gsk_teknologiforst%C3%A5else_Evalueringsrapport_%20uddannelse%20i%20teknologiforst%C3%A5else_spor3.pdf (accessed on 26 July 2022). [57]

Darling-Hammond, L., M. Hyler and M. Gardner (2017), *Effective Teacher Professional Development*, Learning Policy Institute, Palo Alto, CA, https://learningpolicyinstitute.org/sites/default/files/product-files/Effective_Teacher_Professional_Development_REPORT.pdf (accessed on 26 March 2019). [78]

Deeley, S. (2018), *Using technology to facilitate effective assessment for learning and feedback in higher education*, DOI: 10.1080/02602938.2017.1356906. [127]

Department for Education (2022), *Evaluation of the Assistive Technology Training Pilot*, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1087254/AT_Training_Pilot_Evaluation_Report.pdf. [99]

Deutscher Bildungsserver (2022), *Lehrerfortbildungen zum Thema Digitalisierung [Teacher professional development on digitalisation]*, https://www.bildungsserver.de/lehrerfortbildungen-zum-thema-digitalisierung-12811-de.html (accessed on 25 July 2022). [94]

Digital Promise (n.d.), *Microcredential explorer*, https://digitalpromise.org/initiative/educator-micro-credentials/micro-credential-explorer/?a=Topics&b=Technology%20Planning%20%26%20Infrastructure. [67]

Dinse de Salas, S. (2019), *Digitale Medien im Unterricht-Entwicklung professionellen Wissens und professionsbezogener Einstellungen durch Coaching (Dissertation)*, Pädagogische Hochschule Heidelberg, https://opus.ph-heidelberg.de/frontdoor/deliver/index/docId/335/file/Dissertation_Dinse_de_Salas.pdf (accessed on 25 July 2022). [96]

Đurek, V., N. Kadoic and N. Begičević Ređep (2018), *Assessing the digital maturity level of higher education institutions*, doi: 10.23919/MIPRO.2018.8400126. [41]

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. [115]

Ehlers, U. and P. Bonaudo (2020), "DIGI-HE – A strategic reflection tool on digitalisation at European higher education institutions", *European Distance and E-Learning Network (EDEN) Proceedings* 1, pp. 289-298, https://doi.org/10.38069/edenconf-2020-ac0027. [109]

Ejdys, J. and J. Kozlowska (2021), *Acceptance of e-learning at university level during the covid-19 pandemic situation-teachers' and students' perspective*, DOI: 10.17512/pjms.2021.23.2.07. [20]

Estonian Ministry of Education and Research (2014), *The Estonian Lifelong Learning Strategy 2020*, Ministry of Education and Research, Tallinn, https://www.hm.ee/sites/default/files/estonian_lifelong_strategy.pdf (accessed on 18 October 2021). [134]

European Commission (2022), *eTwinning*, https://www.etwinning.net/en/pub/index.htm (accessed on 13 May 2022). [90]

European Commission (2022), *HEIInnovate*, https://www.heinnovate.eu/en (Accessed 25 May 2022). [110]

European Commission (2020), *Commission Staff Working Document Accompanying the Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions "Digital Education Action Plan (2021-2027)"*, European Commission, Brussels, https://eur-lex.europa.eu/legal-content/LT/TXT/?uri=CELEX:52020SC0209 (accessed on 7 April 2022). [1]

European Commission (2015), *European Framework for Digitally Competent Educational Organisations - DigCompOrg*, https://joint-research-centre.ec.europa.eu/european-framework-digitally-competent-educational-organisations-digcomporg_en (accessed on 27 May 2022). [117]

European Commission (2013), *Survey of Schools: ICT in Education - Benchmarking Access, Use and Attitudes to Technology in Europe's Schools*, Directorate-General for the Information Society and Media (European Commission), Brussels, https://doi.org/10.2759/94499. [14]

European Commission/EACEA/Eurydice (2019), *Digital Education at School in Europe*, Publications Office of the European Union, Luxembourg, https://doi.org/10.2797/763. [106]

European Union (2022), *School Education Gateway*, https://www.schooleducationgateway.eu/en/ (accessed on 7 April 2022). [88]

Eurostat (2022), *Individuals' level of digital skills*, https://ec.europa.eu/eurostat/databrowser/view/ISOC_SK_DSKL_I/default/table?lang=en (accessed on 30 May 2022). [50]

Eurydice (2017), *Modernisation of higher education in Europe: academic staff – 2017*, https://ec.europa.eu/info/sites/default/files/209_academic_staff_2017.pdf (Accessed 24 May 2022). [22]

Fraillon, J. et al. (2014), *Preparing for Life in a Digital Age: The IEA International Computer and Information Literacy Study International Report*, Springer International Publishing, Heidelberg, https://research.acer.edu.au/cgi/viewcontent.cgi?article=1009&context=ict_literacy (accessed on 24 January 2020). [10]

France Université Numérique (n.d.), *FUN Ressources*, https://www.fun-ressources.fr/ (accessed on 2 June 2023). [103]

France Université numérique (n.d.), *Se former pour enseigner dans le supérieur - Cours - FUN MOOC*, https://www.fun-mooc.fr/fr/cours/se-former-pour-enseigner-dans-le-superieur/ (accessed on 2 June 2023). [62]

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). [44]

Garet, M. et al. (2008), *The Impact of Two Professional Development Interventions on Early Reading Instruction and Achievement*, US Department of Education, Institute of Education Sciences, http://www.edpubs.org. (accessed on 13 July 2020). [71]

Garet, M. et al. (2016), *Focusing on mathematical knowledge: The impact of content-intensive teacher professional development (NCEE 2016-4010)*, U.S. Department of Education, Institute of Education Sciences. [70]

Géant (2020), *Compendium of National Research and Education Networks in Europe - 2020,*, https://about.geant.org/wp-content/uploads/2021/12/Compendium_FINAL2.pdf. [119]

Ghurbhurun, R. (2020), *If we don't upskill teachers in digital skills, learners will suffer*, https://www.jisc.ac.uk/blog/if-we-dont-upskill-teachers-in-digital-skills-learners-will-suffer-30-nov-2020 (Accessed 27 May 2022). [23]

Gil-Flores, J., J. Rodríguez-Santero and J. Torres-Gordillo (2017), "Factors that explain the use of ICT in secondary-education classrooms: The role of teacher characteristics and school infrastructure", *Computers in Human Behavior*, Vol. 68, pp. 441-449, https://doi.org/10.1016/j.chb.2016.11.057. [15]

Glazerman, S. et al. (2010), *Impacts of Comprehensive Teacher Induction: Final Results from a Randomized Controlled Study (NCEE 2010-4027)*, US Department of Education, Institute for Education Sciences, https://ies.ed.gov/ncee/pubs/20104027 (accessed on 5 December 2020). [68]

Goddard, R. et al. (2015), "A theoretical and empirical analysis of the roles of instructional leadership, teacher collaboration, and collective efficacy beliefs in support of student learning", *American Journal of Education*, Vol. 121/4, pp. 501-530, https://doi.org/10.1086/681925/ASSET/IMAGES/LARGE/FG2.JPEG. [33]

Good Things Foundation (2021), *Future Digital Inclusion*, https://www.goodthingsfoundation.org/what-we-do/our-partnerships/digital-skills-safety/future-digital-inclusion/ (accessed on 31 May 2022). [138]

Government of Ireland (2019), *Almost €100 million investment under Project Ireland 2040 for five major building projects in higher education institutions*, https://www.gov.ie/en/press-release/5b1a84-almost-100-million-investment-under-project-ireland-2040-for-five-ma/ (accessed on 28 May 2022). [122]

Hanafin, J. et al. (2007), *Including young people with disabilities: Assessment challenges in higher education*, DOI 10.1007/s10734-006-9005-9. [30]

Hénard, F. and D. Roseweare (2012), *Fostering quality teaching in higher education: Policies and practices*, https://www.oecd.org/education/imhe/QT%20policies%20and%20practices.pdf. [125]

Hippe, R., A. Pokropek and P. Costa (2021), "Cross-country validation of the SELFIE tool for digital capacity building of vocational education and training schools (in preparation)". [17]

Ifenthaler, D. (2012), *Learning management systems.*, https://doi.org/10.1007/978-1-4419-1428-6_187. [40]

Jacob, B. and L. Lefgren (2004), *The impact of teacher training on student achievement: Quasi-experimental evidence from school reform efforts in Chicago*, https://doi.org/10.2307/3559005. [69]

Jaschik, S. and D. Lederman (2019), *Inside Higher Ed 2019 Survey of faculty attitudes on technology*, https://www.insidehighered.com/news/survey/survey-faculty-attitudes-technology [18]

JISC (2022), *Powering world-class education and research: Advice and guidance*, https://www.jisc.ac.uk/advice (accessed on 28 July 2022). [121]

JISC (2020), *Student digital experience insights survey 2020: question by question analysis of findings from students in UK further and higher education*, https://www.jisc.ac.uk/sites/default/files/dei-2020-student-survey-question-by-question-analysis.pdf. [131]

Jisc (n.d.), *Assistive technology network*, https://beta.jisc.ac.uk/get-involved/assistive-technology-network. [100]

Jones, B. et al. (2019), "Training pre-service general educators in assistive technology competencies for students with visual impairments", *British Journal of Visual Impairment*, Vol. 37/1, pp. 29-39, https://doi.org/10.1177/0264619618814066. [97]

Kampylis, P., Y. Punie and J. Devine (2015), *Promoting effective digital-age learning: A European framework for digitally-competent educational organisations*, Publications Office of the European Union, Luxembourg, https://doi.org/10.2791/54070. [108]

Kennedy, M. (2019), "How we learn about teacher learning", *Review of Research in Education*, Vol. 43, pp. 138-162, https://doi.org/10.3102/0091732X19838970. [72]

Kennedy, M. (2016), "How does professional development improve teaching?", *Review of Educational Research*, Vol. 86/4, pp. 945-980, https://doi.org/10.3102/0034654315626800. [73]

Keune, K. (2022), *Organizational changes announced for newly named Office of Technology and Digital Innovation*, https://it.osu.edu/news/2022/01/12/organizational-changes-announced-newly-named-office-technology-and-digital. [83]

Kools, M. and L. Stoll (2016), "What Makes a School a Learning Organisation?", *OECD Education Working Papers*, No. 137, OECD Publishing, Paris, https://doi.org/10.1787/5jlwm62b3bvh-en. [89]

Kraft, M. and D. Blazar (2017), "Individualized coaching to improve teacher practice across grades and subjects: New experimental evidence", *Educational Policy*, Vol. 31/7, pp. 1033-1068, https://doi.org/10.1177/0895904816631099. [75]

Kraft, M. and J. Papay (2014), "Can professional environments in schools promote teacher development? Explaining heterogeneity in returns to teaching experience", *Educational Evaluation and Policy Analysis*, Vol. 36/4, pp. 476-500, https://doi.org/10.3102/0162373713519496. [63]

Krumsvik, R. (2008), "Situated learning and teachers' digital competence", *Education and Information Technologies*, Vol. 13/4, pp. 279-290, https://doi.org/10.1007/S10639-008-9069-5/FIGURES/1. [101]

Kupriyanova, V., E. Bennetot Pruvot and T. Estermann (2020), *Autonomy, efficiency and effectiveness—Opportunities for higher education: A pilot study. In: Curaj, A., Deca, L., Pricopie, R. (eds) European Higher Education Area: Challenges for a New Decade*, DOI: 10.1007/978-3-030-56316-5_27. [38]

Livingstone, S. et al. (2017), "Maximizing Opportunities and Minimizing Risks for Children Online: The Role of Digital Skills in Emerging Strategies of Parental Mediation", *Journal of Communication*, Vol. 67/1, pp. 82-105, https://doi.org/10.1111/jcom.12277. [49]

MacKay, J. (2019), *Show and 'tool': How lecture recording transforms staff and student perspectives on lectures in higher education*, DOI: 10.1016/j.compedu.2019.05.019. [128]

Marshall, S. (2018), *Shaping the university of the future: using technology to catalyse change in university learning and teaching*, Springer. [42]

Marshall, S. (2012), *E-learning and higher education: understanding and supporting organisational change*, https://ako.ac.nz/assets/Knowledge-centre/NPF-09-025-Understanding-and-Supporting-Organisational-Change-in-e-Learning/E-learning-in-Higher-Education-Case-Study-University.pdf (Accessed 24 May 2022). [116]

Martin, F. et al. (2020), *Examining higher education faculty use of current digital technologies: importance, competence, and motivation*, http://www.isetl.org/ijtlhe/. [25]

Minea-Pic, A. (2020), "Innovating teachers' professional learning through digital technologies", *OECD Education Working Papers*, No. 237, OECD Publishing, Paris, https://doi.org/10.1787/3329fae9-en. [13]

Ministère de l'Éducation Nationale et de la Jeunesse (2018), *L'éducation nationale engagée en faveur d'une école rurale de qualité [National education engaged for high-quality rural schooling]*, https://www.education.gouv.fr/rentree-2018-l-education-nationale-engagee-en-faveur-d-une-ecole-rurale-de-qualite-8375 (accessed on 26 July 2022). [114]

National Forum for the Enhancement of Teaching and Learning in Higher Education (2021), *INDEx survey: final summary report*, https://hub.teachingandlearning.ie/resource/index-survey-final-summary-report/. [130]

National Forum for the Enhancement of Teaching and Learning in Higher Education (2020), *INDEx Findings from Students and Staff Who Teach in Higher Education*, National Forum for the Enhancement of Teaching and Learning in Higher Education, https://www.teachingandlearning.ie/index/ (accessed on 1 September 2021). [129]

New Zealand Qualifications Authority (n.d.), *Qualification Overview: New Zealand Certificate in Adult and Tertiary Teaching (Level 5)*, https://www.nzqa.govt.nz/nzqf/search/viewQualification.do?selectedItemKey=2993. [60]

OECD (2022), *Mending the Education Divide: Getting Strong Teachers to the Schools That Need Them Most*, TALIS, OECD Publishing, Paris, https://doi.org/10.1787/92b75874-en. [28]

OECD (2021), *21st-Century Readers: Developing Literacy Skills in a Digital World*, PISA, OECD Publishing, Paris, https://doi.org/10.1787/a83d84cb-en. [47]

OECD (2021), *Education at a Glance 2021: OECD Indicators*, OECD Publishing, Paris, https://doi.org/10.1787/b35a14e5-en. [52]

OECD (2021), *Education Policy Outlook 2021: Shaping Responsive and Resilient Education in a Changing World*, OECD Publishing, Paris, https://doi.org/10.1787/75e40a16-en. [93]

OECD (2021), *Supporting the Digital Transformation of Higher Education in Hungary*, Higher Education, OECD Publishing, Paris, https://doi.org/10.1787/d30ab43f-en. [124]

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. [16]

OECD (2021), "Teachers' professional learning study: Diagnostic report for the Flemish Community of Belgium", *OECD Education Policy Perspectives*, No. 31, OECD Publishing, Paris, https://doi.org/10.1787/7a6d6736-en. [87]

OECD (2021), *The state of higher education One year into the COVID-19 pandemic*, OECD Publishing. [19]

OECD (2021), "Towards equity in school funding policies", *OECD Education Policy Perspectives*, No. 41, OECD Publishing, Paris, https://www.oecd-ilibrary.org/docserver/6a3d127a-en.pdf?expires=1642414595&id=id&accname=ocid84004878&checksum=1D53BFCFBDA3E73EFAE8B747DF0587C1 (accessed on 17 January 2022). [113]

OECD (2020), "Education Policy Outlook in Estonia", *OECD Education Policy Perspectives*, No. 13, OECD Publishing, Paris, https://doi.org/10.1787/9d472195-en. [111]

OECD (2020), "Education Policy Outlook in France", *OECD Education Policy Perspectives*, No. 15, OECD Publishing, Paris, https://doi.org/10.1787/debad1c1-en. [58]

OECD (2020), *Increasing Adult Learning Participation: Learning from Successful Reforms*, Getting Skills Right, OECD Publishing, Paris, https://doi.org/10.1787/cf5d9c21-en. [141]

OECD (2020), "Learning remotely when schools close: How well are students and schools prepared? Insights from PISA", *OECD Policy Responses to Coronavirus (COVID-19)*, OECD Publishing, Paris, https://doi.org/10.1787/3bfda1f7-en. [36]

OECD (2020), *Making the Most of Technology for Learning and Training in Latin America*, OECD Skills Studies, OECD Publishing, Paris, https://doi.org/10.1787/ce2b1a62-en. [12]

OECD (2020), *PISA 2018 Results (Volume V): Effective Policies, Successful Schools*, PISA, OECD Publishing, Paris, https://doi.org/10.1787/ca768d40-en. [9]

OECD (2020), *Resourcing Higher Education: Challenges, Choices and Consequences*, https://doi.org/10.1787/735e1f44-en. [39]

OECD (2020), *TALIS 2018 Results (Volume II): Teachers and School Leaders as Valued Professionals*, TALIS, OECD Publishing, Paris, https://doi.org/10.1787/19cf08df-en. [35]

OECD (2020), *What Students Learn Matters: Towards a 21st Century Curriculum*, OECD Publishing, Paris, https://www.oecd-ilibrary.org/docserver/d86d4d9a-en.pdf?expires=1641393149&id=id&accname=ocid84004878&checksum=F7EFAE4472E8B93B4E28B566B9CEAFB1 (accessed on 5 January 2022). [133]

OECD (2019), *A Flying Start: Improving Initial Teacher Preparation Systems*, OECD Publishing, Paris, https://doi.org/10.1787/cf74e549-en. [54]

OECD (2019), *Benchmarking Higher Education System Performance*, https://doi.org/10.1787/be5514d7-en. [21]

OECD (2019), *Education Policy Outlook 2019: Working Together to Help Students Achieve their Potential*, OECD Publishing, Paris, https://doi.org/10.1787/2b8ad56e-en. [107]

OECD (2019), *OECD Skills Outlook 2019: Thriving in a Digital World*, OECD Publishing, Paris, https://doi.org/10.1787/df80bc12-en. [7]

OECD (2019), *PISA 2021 ICT Framework*, https://www.oecd.org/pisa/sitedocument/PISA-2021-ICT-Framework.pdf (accessed on 8 April 2022). [48]

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. [11]

OECD (2019), "Transforming pedagogy in Initial Teacher Education: Strategic support for innovation at Ewha Womans University in Korea", *OECD Initial Teacher Preparation Study*, OECD Publishing, Paris, http://www.oecdteacherready.org/wp-content/uploads/2019/03/Korea_Final-REV_Promising-Practice-Korea-2-Flipped-learning-REV.pdf (accessed on 26 May 2022). [61]

OECD (2018), *Developing Schools as Learning Organisations in Wales*, Implementing Education Policies, OECD Publishing, Paris, https://doi.org/10.1787/9789264307193-en. [64]

OECD (2018), *Education Policy Outlook 2018: Putting Student Learning at the Centre*, OECD Publishing, Paris, https://doi.org/10.1787/9789264301528-en. [92]

OECD (2017), *Education Policy Outlook: Italy*, OECD Publishing, Paris, http://www.oecd.org/education/Education-Policy-Outlook-Country-Profile-Italy.pdf (accessed on 11 May 2022). [65]

OECD (2017), *The Funding of School Education: Connecting Resources and Learning*, OECD Reviews of School Resources, OECD Publishing, Paris, https://doi.org/10.1787/9789264276147-en. [51]

OECD (2014), *TALIS 2013 Results: An International Perspective on Teaching and Learning*, TALIS, OECD Publishing, Paris, https://doi.org/10.1787/9789264196261-en. [34]

Office of the Provost (nd), *Learning analytics at UW-Madison*, https://teachlearn.provost.wisc.edu/learning-analytics/. [84]

Opfer, D. (2016), "Conditions and Practices Associated with Teacher Professional Development and Its Impact on Instruction in TALIS 2013"*, OECD Education Working Papers*, No. 138, OECD Publishing, Paris, https://doi.org/10.1787/5jlss4r0lrg5-en. [74]

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. [105]

Papay, J. et al. (2016), "Learning job skills from colleagues at work: Evidence from a field experiment using teacher performance data"*, NBER Working Papers*, No. 21986, https://doi.org/10.3386/w21986. [77]

Parsons, D. et al. (2012), *Impact of teaching development programmes in higher education*. [81]

Poel, E., J. Wood and N. Schmidt (2013), "Including assistive technology in teacher preparation: Exploring one approach", *Learning Disabilities: A Multidisciplinary Journal*, Vol. 19/1, pp. 29-37. [98]

Pont, B., D. Nusche and H. Moorman (2008), *Improving School Leadership, Volume 1: Policy and Practice*, OECD Publishing, Paris, https://doi.org/10.1787/9789264044715-en. [104]

Price, L. and A. Kirkwood (2014), "Using technology for teaching and learning in higher education: A critical review of the role of evidence in informing practice", *Higher Education Research & Development*, Vol. 33/3, https://doi.org/10.1080/07294360.2013.841643. [26]

Redecker, C. (2017), *European Framework for the Digital Competence of Educators: DigCompEdu*, European Commission, Joint Research Centre, https://doi.org/10.2760/159770. [2]

Regjeringen.no (2017), *Digitalisation strategy for the higher education sector 2017-2021 -*, https://www.regjeringen.no/en/dokumenter/digitalisation-strategy-for-the-higher-education-sector-2017-2021/id2571085/?ch=4 (accessed on 28 May 2022). [118]

République française (n.d.), *Parentalité et Numérique*, https://tne.trousseaprojets.fr/parent (accessed on 4 April 2023). [136]

Rienties, B., N. Brouwer and S. Lygo-Baker (2013), *The effects of online professional development on higher education teachers' beliefs and intentions towards learning facilitation and technology*, http://oro.open.ac.uk/39488/. [85]

Rizza, C. (2011), “ICT and Initial Teacher Education: National Policies”, *OECD Education Working Papers*, No. 61, OECD Publishing, Paris, https://doi.org/10.1787/5kg57kjj5hs8-en. [55]

Rosa, A. and G. Taddeo (2021), “Tematiche e prospettive educative e didattiche del digitale nella formazione degli insegnanti [Educational and didactic themes and perspectives on digital teacher training]”, in Pettenati, M. (ed.), *Paese formazione: Sguardo d’insieme e viste particolari da esperienze nazionali di formazione degli insegnanti a cura*, Carocci, https://www.researchgate.net/publication/360866520_Tematiche_e_prospettive_educative_e_didattiche_del_digitale_nella_forma-_zione_degli_insegnanti (accessed on 26 July 2022). [66]

Scott, S. and K. Aquino (2020), *COVID-19 Transitions: higher education professionals’ perspectives on access barriers, services, and solutions for students with disabilities.*, https://higherlogicdownload.s3.amazonaws.com/AHEAD/38b602f4-ec53-451c-9be0-5c0bf5d27c0a/UploadedImages/COVID-19_/AHEAD_COVID_Survey_Report_Barriers_and_Resource_Needs.pdf. [32]

Stoll, L. et al. (2006), “Professional learning communities: A review of the literature”, *Journal of Educational Change*, Vol. 7/4, pp. 221–258, https://doi.org/10.1007/s10833-006-0001-8. [91]

SURF (2022), *About SURF Cooperation*, https://www.surf.nl/en/about-surf (accessed on 28 July 2022). [120]

Tammets, K. et al. (2019), *Aruanne: Koolide digivõimekuse toetamiseks enesehindamis- ja juhtimisinstrumendi Digipeegel arendamine [Report: Development of a self-assessment and management instrument Digital Mirror to support the digital capability of schools]*, Tallinn University/Institute of Digital Technologies/Center for Educational Technology, Tallinn. [112]

Thillay, A., A. Jean and Q. Vidal (2020), “France: Les banques de ressources numériques éducatives (BRNE) (Banks of educational digital resources)”, *Education continuity during the Coronavirus crisis*, OECD Publishing, Paris, https://oecdedutoday.com/wp-content/uploads/2020/09/France-Banks-of-educational-digital-resources.pdf (accessed on 24 April 2022). [102]

Timperley, H. et al. (2007), *Teacher Professional Learning and Development: Best Evidence Synthesis Iteration*, New Zealand Ministry of Education, Wellington, http://educationcounts.edcentre.govt.nz/goto/BES (accessed on 26 March 2019). [79]

Tømte, C. et al. (2019), *Digitalisation in higher education: mapping institutional approaches for teaching and learning*, DOI: 10.1080/13538322.2019.1603611. [86]

UK Government (2022), *Free qualifications for adults with low digital skills - GOV.UK*, https://www.gov.uk/guidance/free-qualifications-for-adults-with-low-digital-skills (accessed on 31 May 2022). [137]

Ulferts, H. (ed.) (2021), *Teaching as a Knowledge Profession: Studying Pedagogical Knowledge across Education Systems*, Educational Research and Innovation, OECD Publishing, Paris, https://doi.org/10.1787/e823ef6e-en. [3]

US Office of Educational Technology (2021), “Parent and Family Digital Learning Guide”. [135]

van Deursen, A. and J. van Dijk (2014), “The digital divide shifts to differences in usage”, *New Media & Society*, Vol. 16/3, pp. 507-526, https://doi.org/10.1177/1461444813487959. [46]

Viennet, R. and B. Pont (2017), “Education policy implementation: A literature review and proposed framework”, *OECD Education Working Papers*, No. 162, OECD Publishing, Paris, https://doi.org/10.1787/fc467a64-en. [132]

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. [53]

VSNU (2018), *Professionalisering van docenten aan de universiteit [Professionalisation of university lecturers]*, Vereniging van Universiteiten (VSNU) [Association of Universities in the Netherlands], The Hague, https://www.universiteitenvannederland.nl/files/documenten/Professionalisering%20van%20docenten%20aan%20de%20universiteit.PDF (accessed on 29 July 2022). [59]

Willermark, S. (2018), “Technological pedagogical and content knowledge: A review of empirical studies published from 2011 to 2016”, *Journal of Educational Computing Research*, Vol. 56/3, pp. 315-343, https://doi.org/10.1177/0735633117713114/FORMAT/EPUB. [4]

Notes

[1] Among EU countries, the proportion was 66% on average and ranged from 49% in Ireland to 84% in Lithuania.

[2] On average across EU countries, 39% of lower secondary teachers felt well or very well prepared to use ICT for teaching when they completed their initial education or training (ranging from less than 25% in Austria and Finland to 60% and more in Cyprus, Hungary and Slovenia).

[3] 16% on average across the EU, ranging from 9% in Slovenia and the Flemish Community of Belgium to 26% in Croatia.

[4] For the purpose of the analysis of TALIS data, VET teachers were defined as those who reported teaching practical and vocational skills in the survey year, regardless of their type of programme or school. This data was available for Sweden, Portugal, Denmark, Slovenia, Canada (Alberta) and Türkiye (OECD, 2021, p. 17[16]).

[5] On average across EU countries, the relationship between the use of ICT and the share of students with SEN is not statistically significant.

[6] These include carefully selecting pages relevant to the tasks, limiting visits to irrelevant pages (strictly focused navigation), and actively navigating both single- and multiple-source items (actively explorative navigation) (OECD, 2021[47]).

[7] Such centres exist, for instance in **Ghent University, the University of Helsinki, Université Grenoble Alps, Ludwig Maximilian University of Munich, RWTH Aachen University, University of Hamburg, Delft University of Technology, Leiden University, Utrecht University, Universidad Autonoma de Madrid, among many others.**

[8] https://education.ec.europa.eu/focus-topics/digital-education/action-plan/european-digital-education-hub

8 Human resource policies for digital education

This chapter considers how human resources policies can be adapted to support the development of high-quality digital education. It highlights some of the ways in which educators' working conditions, career structures and professional support can facilitate or constrain their ability to make effective use of digital education technologies. It also outlines some promising policies that can help educators to make time to engage with digital education, reward their efforts to do so and provide them with appropriate technical and professional support.

Introduction

The digital transformation changes occupations and workplaces, transforming both the types of tasks workers engage in and the way in which they are carried out. Digital work environments require workers to perform a greater variety of tasks (including, for example, managing, communicating and tasks involving reading, writing and numeracy) and to make more intensive use of general cognitive skills (OECD, 2019, p. 39[1]). As digital technologies increasingly permeate education systems, schools and classrooms, they have transformed and will continue to transform how education administrators, school leaders and teachers perform their work.

As discussed in Chapter 7, a lack of capacity among educators can inhibit the progress of digital transformation within education systems. Beyond a lack of capacity, insufficient incentives to use digital technologies in teaching and learning or structural barriers might also jeopardise the integration of digital technologies into teaching. Human resource policies - such as career structures, teacher workload and staffing - are key factors determining educators' ability and motivation to integrate digital technologies in their teaching and learning. Aligning human resource policies with the expectations on educators to improve their digital capacities is thus paramount to realise the potential of digital education.

Acquiring the necessary skills to effectively use digital technologies as well as adapting pedagogical practices to integrate digital technologies require substantive initial time investments, although this investment potentially can pay off in terms of future efficiency gains. Yet, high workloads and the growing range of activities educators need to involve themselves with can leave scarce time to focus on development of digital capacity. Adapting educators' working time arrangements to allow sufficient time for these new tasks and acknowledging educators' time investments in digital education are essential first steps to facilitate successful digital education.

Furthermore, effective incentive structures are needed to motivate educators to adapt their teaching practices to integrate digital technologies. This requires the adaptation of evaluation and career progression frameworks to recognise educators' efforts invested in building digital skills and pedagogies. Such initiatives are particularly crucial in the higher education sector, where there is a long-standing perception that delivering excellent teaching is less rewarding for academics than high achievement in research activities. This perception often limits motivation for innovation of teaching practices.

Effectively integrating digital technologies into teaching can only succeed with the support of appropriately trained technical staff that are available to assist teachers and students with using digital technologies. Education institutions must thus adapt their staffing and compensation models to dedicate resources towards these tasks.

Thus, the digital transformation of education systems is profoundly changing the way educators work. The policies that shape teachers' and educators' working conditions and their use of time have an important role to play in facilitating the take-up and use of digital education technologies. Career structures, professional standards and appraisal systems can provide educators with incentives to use digital technologies, just as working time arrangements can promote educators' collaborative work using digital resources.

This chapter seeks to analyse the types of challenges education systems currently face in motivating and empowering educators to use digital technologies and presents promising approaches observed in OECD and EU countries. In particular, it examines some key questions for policy makers:

- What policies can help educators to overcome time constraints and other barriers that inhibit their effective engagement with digital education technologies?
- What incentive structures are needed to encourage educators' uptake of digital technologies for teaching?

- What professional roles and skills are needed in education institutions to foster the take-up and effective use of digital education technologies (e.g. IT specialists, IT resource librarians etc.)?

Recent developments and current challenges

As discussed above, digitalisation creates new demands for human resources and expertise in the area of maintenance of digital infrastructure and technical support. The following sections summarise existing evidence about the extent to which human resources policies in OECD education systems are adapted to digital teaching practices and take stock of the key challenges policy makers are facing.

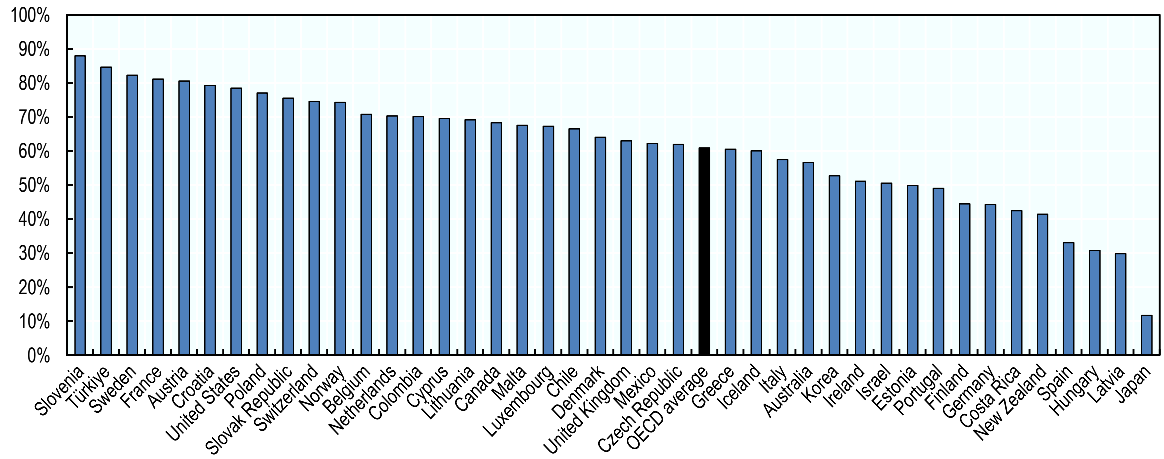
Time constraints often pose barriers to educators' ability to integrate digital technologies in education

The use of digital technologies can help teachers to carry out routine tasks more efficiently but also adds new demands on their time

In schools, the greater use of digital technologies has increased the complexity and diversity of tasks teachers are expected to engage in (OECD, 2019[2]). Even before the pandemic, many teachers reported their workload to be a major source of stress (OECD, 2020[3]). The move towards digital education can place additional demands on teachers' time. For instance, teachers need time to prepare digital education materials, whether to complement in-person lessons, to engage in remote instruction or to deliver materials to students attending hybrid classes from home. Evidence from PISA suggests that, already in 2018, only 61% of 15-year-olds in OECD countries attended a school whose principal considered teachers had sufficient time to prepare lessons integrating digital devices. In Japan, Latvia, Hungary and Spain, fewer than 40% of students were in schools whose principals reported that teachers had sufficient time to prepare lessons with digital education materials Figure 8.1.

Figure 8.1. Teachers' time to prepare digitally enhanced lessons

Percentage of students in schools whose principal agreed or strongly agreed that teachers have sufficient time to prepare lessons integrating digital devices



Source: OECD (2020[4]), *PISA 2018 Results (Volume V): Effective Policies, Successful Schools*, https://doi.org/10.1787/ca768d40-en, Table V.B1.5.15.

On the other hand, digital technologies can also help teachers to make better use of their time by performing more of their responsibilities more efficiently or automating routine tasks. Many teachers already rely on digital tools to save time and enhance the way they engage in administrative tasks, lesson preparation, assessment, professional learning or collaboration (OECD, 2019[2]). Evidence from a survey of over 2 000 teachers in Canada, Singapore, the United Kingdom and the United States conducted prior to the pandemic also suggests that teachers spend between 20% and 40% of their time on activities that could be automated. According to a study, lesson preparation, administration, evaluation and feedback hold particularly significant potential for automation, which could help teachers to spend more of their time focusing on core instructional activities (McKinsey, 2020[5]). Nonetheless, not all tasks with a potential for automation are likely to be carried out autonomously by digital technologies or removed from teachers' control. Most smart technologies are still designed as socio-technical or hybrid systems that complement the work of teachers who retain control and oversight over the process (OECD, 2020[6]).

Similar patterns can be observed in higher education systems in European and OECD countries. Although HEIs began to adopt digital technologies for teaching decades ago, much of the early uptake of digitalisation was driven by individual educators who had expertise in, and enthusiasm for, digitally enhanced delivery (Tømte et al., 2019[7]). On a wider scale, educators in higher education institutions often report a lack of time and resources to develop digital content and pedagogies. For example, recent OECD analysis of digital maturity in Croatia's higher education system highlighted the lack of time that higher education staff have available to integrate digital technologies in teaching, and the lack of extrinsic motivation for them to do so (OECD, 2023[8]).

Higher education workload allocation models may be maladaptive to digitalisation goals, due to the need to balance working time across missions

Higher education institutions face an even more complex situation than schools do with regard to making space for development of staff digital capacity. Higher education institutions have a broader range of missions than schools– typically defined as some balance of teaching, research, and external engagement/service. Most academics work in institutions that balance these three missions, and individual academics hold appointments that combine responsibility for each. As a result, workload allocation models are often defined at the system, subsector or institution level, to structure the distribution of academic staff time among their responsibilities. Teaching responsibilities of academic staff may be denominated in instructional contact hours per week, student headcount, or courses per semester or year. Regardless of the metric used – courses, hours, or credits – workload models map out responsibilities on a semester or annual basis.

Academic workload models operate on a short-term calendar: over a semester, or year. By common agreement among experts in digital pedagogy, the upfront costs of digital transition or new digital course creation are higher than the time cost of producing or reproducing a traditional in-person course. The cost of transitioning to or implementing digital technologies in higher education teaching are strongly front-loaded, with efficiency gains being potentially realised in the medium to long term. By some estimates, it takes three or more years for the net time costs associated with digital provision to be lower than those of in-person instruction (Gregory and Lodge, 2015[9]). As a result, the time horizons of academic workload models and digital education costs are mismatched, leading to an underinvestment of staff time in transitioning towards a greater use of digital technologies in teaching. An underinvestment of time in the take-up and use of digital technologies means that learners have less access to them than might be desirable, or they are put to use at a lower level of quality.

External incentives and supports to educators to integrate digital tools in their practice appear limited

Career structures and reward systems in schools rarely reflect teachers' efforts to improve their capacity for digital education

The upfront investments educators need to make in order to acquire the necessary skills for digital education and adapt their teaching practices to digital tools call for adequate incentive structures to encourage the integration of digital technologies in education. Human resource policies can provide effective instruments to policy makers to reward innovative uses of digital technologies and acknowledge educators' efforts in the area of digital education.

For instance, well-designed career structures can support an effective deployment of education staff and make the most of their skills in education institutions (OECD, 2019[10]). In 2018, few OECD and EU countries had multi-stage vertical career structures that enable teachers to be promoted based on a succession of formal positions with distinct task profiles and progressive responsibilities (OECD, 2019[10]). Such career pathways may encourage teachers to engage in a wider variety of roles related to digital education in their schools (e.g. as digital co-ordinators, taking leadership positions focused on digital resources management in support of the school leader) and have their time investment and efforts formally recognised.

Evidence from European countries shows that across all levels of school education, the methods most commonly applied by schools to incentivise teachers for the use of ICT in teaching and learning include the provision of additional training hours and ICT equipment for their classroom (European Commission, 2019[11]). However, only one-third of lower secondary students attends schools that offer such incentives to teachers and one-fifth of students in primary education (European Commission, 2019[11]). At the sub-system and system level, little information is available on whether and how improved efficiency in digital resources' use is rewarded and stimulated. In PISA 2018, only about 57% of 15-year-old students across OECD countries attended schools whose principal reported that teachers were provided with incentives to integrate digital devices into their teaching (OECD, 2020[4]).

Low perceived prestige of teaching activities and lack of external support staff limits motivation of higher education teaching staff to develop digital pedagogies

The problem of digital skill development for pedagogy in higher education is compounded because, for many academics, teaching is seen as a lower prestige activity than research, with fewer career rewards: Research-intensive institutions tend to prefer hiring academic staff with established records of achievement in research, and development of teaching skills does not feature highly in promotion and career advancement criteria, or in securing tenure (Blackmore and Kandiko, 2011[12]; OECD, 2020[13]). As a consequence, the incentives for participation in training in teaching are relatively low. In addition, academics with a high focus on research, especially those engaged in contract research, are able to delegate some of their teaching load to teaching assistants (Marini, Locke and Whitchurch, 2019[14]; Finkelstein, 2010[15]; Enders and Musselin, 2008[16]), further reinforcing the message that teaching is subordinate to research.

Educators in teaching-led post-secondary institutions understandably place a priority on their pedagogical responsibilities. However, similar to the situation in schools, they often find that they lack the time and institutional support to adopt digital technologies. For example, in a recent survey of English further education educators only 38% agreed their organisation provides guidance about the digital skills they need, and only 22% agreed they had time to explore new digital tools and approaches (Ghurbhurun, 2020[17]). A systematic meta-review of academic staff perspectives on the use of technology in assessment processes in higher education also noted a lack of integration of technology use for specific purposes (i.e. assessment) within an overall pedagogic framework, a lack of alignment of technological and operational supports for the use of technology, and a lack of a broad available empirical evidence on the efficacy, staff experiences and resources required by the use of technology (Brady, Devitt and Kiersey, 2019[18]).

The terms and conditions of employment in higher education may also be a limiting factor in the take-up of training for digital competence, particularly for higher education educators who are employed on a temporary or part-time basis, who may have few incentives to engage in the development of their capabilities as digitally competent teachers, few opportunities to do so, or may be unaware of professional development opportunities. These part-time, fixed-term educators form an important share of the instructional workforce in many OECD and EU higher education systems (OECD, 2020[13]). Lack of time or access to training and supports is most especially the case for educators teaching in programmes offered at the post-secondary non-tertiary education qualifications or short-cycle tertiary education.

Technical support staff is needed to facilitate the integration of digital technologies in education

Beyond policies that enable and encourage educators to use digital technologies in teaching, education systems also require skilled human resources to roll out and maintain digital infrastructure in education institutions. Currently, education systems across the OECD face significant gaps in the availability of technical assistance at school levels. Across the OECD, only 54% of 15-year-old students attended schools whose principal reported having sufficiently qualified technical assistant staff, ranging from less than 30% in Greece, Ireland and Portugal to more than 70% in Lithuania, Austria, Sweden, the Netherlands and Denmark (and in contrast to more than 90% in countries like Norway and Singapore). On average, this lack of technical assistant staff was more pronounced in disadvantaged schools (OECD, 2020[4]; OECD, 2020[19]).

Higher education institutions, with their wider range of deployed digital technologies across diverse activities and missions, face even greater pressure to attract and retain skilled IT support staff. Higher education institutions tend to maintain a presence of skilled IT staff on site, providing user support, network maintenance, and software, hardware and security updates. The skilled staff needed for these roles are also generally in demand in a context of wide-ranging digital transformation across the entire economy and may be presented with a wider range of career development opportunities in other sectors. For example, in a recent study of campus IT professionals in the **United States**, 50% reported feeling overworked and being understaffed, while more than 40% reported frequent IT staff turnover, leading to a general trend of less experienced staff being employed on campus (APOGEE, 2022[20]). Similarly, a recent report on the state of digital technology in the further education sector in the **UK** highlighted a growing shortage of ICT staff and a rising ratio of users supported per ICT support staff member (Jisc, 2020[21]).

Promising approaches for adapting human resources frameworks to support digital education development

Review working time and staff arrangements in education institutions to make time and space for digital education

Using digital devices to enhance teaching requires significant time resources. Although the use of digital education technology promises to make some aspects of teachers' work more efficient (see Chapter 1) and online platforms give teachers access to an abundance of learning resources, navigating these resources, preparing digitally enhanced lessons and learning how to do so effectively takes time (Minea-Pic, 2020, p. 23[22]). In PISA 2018, only 60% of 15-year-old students attended a school whose principal reported that teachers had sufficient time to prepare lessons integrating digital devices (OECD, 2020[4]). Even fewer, only 44% of students, attended schools where teachers had a regular scheduled time to share, evaluate or develop instructional materials and approaches that use digital devices (OECD, 2020[19]; OECD, 2020[4]).

While there is "no one-size-fits-all" approach to an effective distribution of teachers' time, policy frameworks that regulate teachers' use of time at the system level can support a more effective use of teachers' time for digital education. Many OECD education systems regulate teachers' time use by focusing primarily on teaching hours (OECD, 2019[10]). However, teachers carry out a significant number of tasks and activities outside of their teaching hours and education systems need to better reflect the time teachers are expected to work on tasks involved by digital education. Digital education amplifies this pattern as teachers need to devote additional time to adapt lesson plans to the introduction of digital tools in their teaching, reconsider and redesign assessment techniques (whether or not relying on digital technologies for assessment) or engage in professional learning for digital education. Implementing workload-based regulation for teachers' working time, adjusting teaching loads (particularly for novice teachers who are not necessarily more self-efficient in integrating digital technologies in their teaching activities) or reducing the teaching time for teachers who take on management activities related to digital education in the school can enable a more effective use of teachers' time.

Beyond policy frameworks at the system level, granting more autonomy to school leaders in the allocation of teachers' time to better account for local needs and strategic priorities can also promote a better and more efficient use of teachers' time. Such measures need to be accompanied, however, by support to school leaders (e.g. guidance, professional learning opportunities) who may lack the capacity or models to build on when redesigning the distribution of teachers' time or may risk undermining teachers' autonomy in their time use (OECD, 2019[2]; Boeskens and Nusche, 2021[23]). Finally, staff arrangements in schools can also enable a more effective use of teachers' and school leaders' time for digital education. While evidence on the effectiveness of hiring additional support staff for easing teachers' administrative burden remains mixed (OECD, 2019[2]; Boeskens and Nusche, 2021[23]), digital education will likely continue to transform the tasks performed by teachers and thereby, their need for support.

In higher education, academic workload policies are sometimes directly set by government, but are often the result of collective bargaining at the sector or institutional level or set by university boards and management. This means that options for policy steering by Ministerial authorities through the modification of workload models may be limited. Nonetheless, quality assurance bodies and national centres for teaching and learning should prioritise near-term initiatives that give recognition and support to the investment of instructional time in the effective use of digital technologies. Such initiatives could include supporting institutional policies that provide course reductions and summer stipends for course development and supporting augmented professional supports that free up staffing time to focus on the development of digital course materials.

Policies that aim to make time and space for educators to work on digital development may work best when included as part of a more holistic multi-dimensional policy effort. For example:

- In **France**, following the Bertrand report, which provided recommendations for transforming higher education policy in France (Bertrand, 2014), the French government instituted a number of reforms aimed at improving teaching and learning in higher education, including through the use of digitalisation. Notably, the government created a new Directorate General for Higher Education and Professional Integration within the Ministry for National Education, Higher Education and Research, and a new mission unit, the Mission for Pedagogy and Digitalisation in Higher Education (MiPNES), which supports and co-ordinates opportunities for key actors to exchange practices and discuss improvements in teaching and learning. Importantly, these reforms were conducted in conjunction with other regulatory changes to human resources policy. From 2018, for example, new assistant professors with both teaching and research responsibilities are allowed to devote one-sixth of their allocated teaching time for professional learning (OECD, forthcoming).

In the longer run, governments need to focus on both better accounting for teaching costs and piloting new workload models. Governments that have invested in the development of costing models for teaching should work to analyse teaching costs by mode of teaching, and work to account for blended learning environments. Teaching costs should include (but not be limited to) information communication technology infrastructure, redevelopment of content, supporting students, managing assessment on line and other service costs (Tynan, Ryan and Lamont-Mills, 2015[24]). Having a true account of costs can provide a basis for governments, sectoral associations, and institutions to rethink workload models, implementing multi-year instructional workload models that permit those academics who make the upfront investment of time in digital adoption to capture in later years the benefits of their efforts.

Higher education institutions can also reduce the costs of in-person to digital transition or new digital course development that is borne by instructors by providing them with expert professional staff support (course design professionals), or, by providing them with one-off reductions in their course workload. Higher education institutions often appear to limit the time burden associated with digital instruction by capping course sizes. In higher education institutions in the **United States**, online class sizes may be capped at lower levels than the same course taught in person (Xu and Xu, 2019[25]), and in **Ireland** the academic workload model for digital courses proposed by the Teachers' Union of Ireland calls for extra instructional contact hours to be awarded to those teaching courses on line (as compared to in-person instruction), with a two hour online course of 60-80 students counted as equivalent to 12 instructional contact hours per week, potentially an instructor's entire instructional workload for the semester (Consortium, 2020[26]).

Designing incentive mechanisms and career reward structures to encourage teachers' engagement in digital education

In PISA 2018, only 57% of 15-year-old students attended a school whose principal agreed or strongly agreed that teachers are provided with incentives to integrate digital devices in their teaching. Among participating OECD countries, this proportion ranged from 90% or more in Iceland, Lithuania, the Netherlands, Poland, Slovenia and Türkiye, to 20% or less in Spain, Mexico and Korea (OECD, 2020[4]). However, given the effort and upfront investment it can take teachers to enhance their practice with digital education technologies, the right incentive structures must be put in place to encourage teachers to successfully use digital tools in the classroom. However, incentives must be carefully designed to avoid the risk of crowding out teachers' intrinsic motivation to engage in the pedagogical use of digital technologies and avoid exacerbating existing digital divides within the teaching profession (OECD, 2019[27]; OECD, 2019[10]).

Teachers may benefit from financial rewards, career advancement, reduced teaching hours, competitions that award prizes, additional training hours and additional digital equipment for the classroom (Wastiau et al., 2013[28]). Including digital competencies or practices in professional teaching standards, evaluation and certification frameworks or ITE programmes are additional levers that can incentivise and signal the recognition of teachers' use of digital technologies in the classroom. Some countries have thus designed their reward and promotion structures to reflect educators' engagement with digital education:

- In **Croatia**, sharing innovative teaching methods or creating digital content are listed as evaluation criteria for primary and secondary school teachers, teaching assistants and school principals (Ministry of Science and Education, 2019[29]). Among other aspects, these criteria determine the allocation of annual awards for teaching excellence. They are also used to assess educators' eligibility for career progression (Ministry of Science and Education, 2023[30]).

In addition to using teachers' engagement with digital education to determine vertical career progression, horizontal career development opportunities can create incentives for digital education. Some OECD and non-OECD countries have successfully designed career pathways that offer vertical and horizontal opportunities for professional growth related to digital education:

- In the **Slovak Republic,** teachers can have a career that is both differentiated vertically (beginning teacher, independent teacher, teacher with first certification, teacher with second certification) and horizontally, enabling teachers to take on specialist positions such as the role of a digital co-ordinator, and thereby develop skills and devote themselves more in-depth to this specific area (OECD, 2019[10]).
- **Singapore** (a country widely recognised for digitalisation of its education system) also combines vertical career advancement with horizontal specialisation, enabling teachers to go into a teaching track, a specialist track or a leadership track. Multi-stage career structures also matter for school leadership, particularly in the context of ever-increasing responsibilities of school leaders for the acquisition, management and safe use of digital technologies in their schools.

Recognising skills acquired by teachers as they try to develop innovative teaching practices with digital technologies is critical to encourage teachers' autonomous engagement and continued efforts in such activities. Digitalisation itself can provide new opportunities for recognising teachers' invested time, efforts and acquired skills while integrating digital technologies in their teaching. New methods and tools (e.g. open badges, micro-credentials) have emerged for certifying and recognising a broader variety of skills. For instance, micro-credentials enable teachers to choose a specific skill they wish to develop or have recognised, gather the evidence underpinning their mastery of the skill (e.g. instruction videos) and have it recognised by a reviewer in a credentialing platform (Minea-Pic, 2020[31]).

Providing teachers with the necessary incentives to engage in such skills certification tools also raises the question of how these emerging forms of certification can be recognised as part of official teacher professional development schemes and whether they matter for career progression and compensation. As mentioned in Chapter 7, in the **United States**, a number of states have enabled educators to use micro-credentials to fulfil their continuing education requirements. Other states have experimented with the use of micro-credentials as part of teacher licensure and in some states, micro-credentials have provided pathways for transitioning to more advanced leadership activities (Minea-Pic, 2020[31]; DeMonte, 2017[32]).

Enhance the prestige of teaching in higher education to promote pedagogical innovation

In most higher education systems, moves to mandate training or professional development for higher education educators are likely to fail: academics enjoy autonomy (Watson, 2007[33]), have advanced training in their field of specialisation (Eurydice, 2017[34]) and have a range of duties – research and engagement, in particular – beyond teaching. Therefore, governments and HEI leaders wishing to increase the uptake of training in the use of digitalised delivery need to create opportunities for staff to upskill that are adapted to the incentives they face as professionals, and to the prerogatives of the institutions in which they work.

As noted above, one of the problems faced by some HEIs in trying to implement digitalisation in their teaching programmes is that, for many university academics, teaching is a lower status activity than research (Blackmore and Kandiko, 2011[12]). In some OECD countries, HEIs have sought to improve the standing of higher education teachers and the prestige of the higher education teaching profession by including the quality of teaching as a strategic priority for the institution, assigning explicit responsibility for fostering teacher quality to (for instance) heads of departments, establishing a teaching and learning framework that reflects the values of the institution, and creating annual awards that honour and recognise excellent teaching (Hénard and Roseweare, 2012[35]). Institutional recognition of teaching excellence is now common in European HEIs (Efimenko et al., 2018[36]). A 2017 survey of 78 HEIs across five European countries showed that these awards, designed to motivate educators to improve the quality of their teaching, can encourage innovation in teaching and raise awareness of the importance of improving teaching (Efimenko et al., 2018[36]). Some HEIs have created incentives designed, for example, to increase teacher motivation to engage in pedagogical innovation. For instance, at the University of Edinburgh, in **Scotland (United Kingdom)** and the University of Canterbury, in **New Zealand** academics with a record of excellence in teaching and learning are given additional time to engage in the scholarship of teaching and learning and to share their practice with colleagues (University of Edinburgh, 2017[37]), (University of Canterbury, 2021[38]).

Build sufficient technical and specialist support structures for educators and students using digital technologies for teaching and learning

As education systems increasingly rely on digital tools, human resource policies must be adapted in order to ensure the availability of technical support staff to maintain digital infrastructure in education institutions and assist teachers and students with technical problems as they arise. In school education, many education systems have attempted to meet these needs by appointing digital co-ordinators at a school level:

- According to Eurydice data, about half European countries have created formal positions for teachers tasked with supporting the effective use of digital technologies in schools such as digital co-ordinators in the **Flemish Community of Belgium** (OECD, 2021[39]) and the **Slovak Republic** (Santiago et al., 2016[40]), or e-learning co-ordinators in **Austria** (Nusche et al., 2016[41]). Despite some variation in the nature of these roles between education systems and schools, they tend to entail both pedagogical tasks – such as consulting teachers on the use of digital technologies and organising in-house training – as well as technical tasks – such as the installation and maintenance of IT equipment or installation and configuration of software (European Commission/EACEA/Eurydice, 2019, p. 95[42]).
- Likewise, **Uruguay** accompanied a reform to promote digital inclusion (the *Plan Ceibal*) with the creation of support teacher roles (*Ceibal* teachers) who specialised in advising their peers and helping them to use digital devices effectively for teaching (Santiago et al., 2016[43]).

Currently, most education systems rely on experts within the teaching body to take on responsibilities as digital co-ordinators. However, to ensure that this role is given the attention it deserves, and the responsible experts have sufficient time resources to support teachers and students in the capacity needed, these roles need to be reflected in compensation and teaching commitments. Some education systems – including **France** and the **Czech Republic** – thus grant additional financial rewards to digital co-ordinators (European Commission/EACEA/Eurydice, 2019[42]).

Higher education institutions are also increasingly recognising the need for specialist professionals who are able to support educators to deploy digital technologies in innovative ways for teaching and learning. For example, the job roles of "digital learning technologist," and "educational technologist" are already well-established in higher education systems in North America and are becoming more prevalent in other regions. This class of staff is often highly qualified and aims to build bridges between technical and pedagogic knowledge, in order to support and advise teaching academics on the effective development of online and digitalised learning material (OECD, 2023[8]).

Key messages

Whilst digital technologies provide opportunities to enhance quality and efficiency of education delivery in the medium and long run, integrating digital tools into teaching practices initially requires significant time investments. Currently, educators across OECD and EU countries are given little time and incentives to enhance their pedagogies through the use of digital technologies. This problem is particularly acute at higher education levels, where teaching– and thus time invested in pedagogical innovation – suffers from a low standing relative to research activities. Human resource policies can be adjusted to help educators make time to engage with digital education and reward their efforts to do so. This chapter presents a range of such policies, including reviewing working time arrangements and considering teachers' engagement with digital pedagogies in evaluations and promotion decisions.

In addition, the analysis in this chapter highlights the importance of providing educators with the necessary technical support to navigate increasingly digital education settings. Currently, education systems across the OECD and EU record a severe lack in technical support staff. In this light, this chapter considers human resource policies to provide specialist support to educators for effective digital education.

References

APOGEE (2022), *Overcoming campus IT staffing nd expertise gaps*, https://www.apogee.us/wp-content/uploads/2022/09/E-book_Overcoming-Campus-IT-Staffing-and-Expertise-Gaps_FINAL_092022.pdf. [20]

Blackmore, P. and C. Kandiko (2011), "Motivation in academic life: a prestige economy", *Research in Post-Compulsory Education*, Vol. 16, pp. 399-411, https://doi.org/10.1080/13596748.2011.626971. [12]

Boeskens, L. and D. Nusche (2021), "Not enough hours in the day: Policies that shape teachers' use of time", *OECD Education Working Papers No. 245*, https://www.oecd-ilibrary.org/docserver/15990b42-en.pdf?expires=1612870680&id=id&accname=guest&checksum=0EE68B29EDB55C08FF4E0B79834AA3B5 (accessed on 9 February 2021). [23]

Brady, M., A. Devitt and R. Kiersey (2019), "Academic staff perspectives on technology for assessment (TfA) in higher education: A systematic literature review", *British Journal of Educational Technology*, Vol. 50/6, pp. 3080-3098, https://doi.org/10.1111/BJET.12742. [18]

Consortium, A. (2020), "MOU Position Paper One: Online Delivery". [26]

DeMonte, J. (2017), *Micro-credentials for Teachers: What Three Early Adopter States Have Learned So Far*, American Institute for Research, https://openbadges.org/about/. (accessed on 12 October 2020). [32]

Efimenko, E. et al. (2018), *Enhancement and recognition of teaching and learning in higher education: The impact of teaching and excellence prizes*, https://eua.eu/downloads/content/2018_j02_t7_efimenko%20et%20al_onlineversion_journal.pdf (accessed on 11 May 22). [36]

Enders, J. and C. Musselin (2008), "Back to the Future? The Academic Professions in the 21st Century", in *Higher Education to 2030, Volume 1, Demography*, OECD Publishing, Paris, https://doi.org/10.1787/9789264040663-5-en. [16]

European Commission (2019), *2nd Survey of Schools: ICT in Education - Objective 1: Benchmark progress in ICT in schools*, Luxembourg: Publications Office of the European Union, https://doi.org/10.2759/23401. [11]

European Commission/EACEA/Eurydice (2019), *Digital Education at School in Europe*, Publications Office of the European Union, Luxembourg, https://doi.org/10.2797/763. [42]

Eurydice (2017), *Modernisation of higher education in Europe: academic staff*, Publications Office of the European Union, https://ec.europa.eu/info/sites/default/files/209_academic_staff_2017.pdf (accessed on 24 May 2022). [34]

Finkelstein, M. (2010), "Diversification in the academic workforce: The case of the US and implications for Europe", *European Review*, Vol. 18/1, pp. 141-156, https://doi.org/10.1017/S1062798709990366. [15]

Ghurbhurun, R. (2020), *If we don’t upskill teachers in digital skills, learners will suffer*, https://www.jisc.ac.uk/blog/if-we-dont-upskill-teachers-in-digital-skills-learners-will-suffer-30-nov-2020 (accessed on Accessed 27 May 2022). [17]

Gregory, M. and J. Lodge (2015), “Academic workload: the silent barrier to the implementation of technology-enhanced learning strategies in higher education”, *Distance Education*, Vol. 36/2, pp. 210-230, https://doi.org/10.1080/01587919.2015.1055056. [9]

Hénard, F. and D. Roseweare (2012), *Fostering quality teaching in higher education: Policies and practices*, OECD Publishing, https://www.oecd.org/education/imhe/QT%20policies%20and%20practices.pdf. [35]

Jisc (2020), *IT infrastructure reviews: key findings | Jisc*, https://www.jisc.ac.uk/reports/it-infrastructure-reviews-key-findings (accessed on 6 July 2022). [21]

Marini, G., W. Locke and C. Whitchurch (2019), *The future higher education workforce in locally and globally engaged higher education institutions: a review of literature on the topic of the academic workforce*, Centre for Global Higher Education, UCL Institute of Education, https://discovery.ucl.ac.uk/id/eprint/10121427/1/wp43.pdf (accessed on Accessed 24 May 2022). [14]

McKinsey (2020), *Artificial intelligence in education: How will it impact K-12 teachers*, https://www.mckinsey.com/industries/public-and-social-sector/our-insights/how-artificial-intelligence-will-impact-k-12-teachers (accessed on 18 August 2020). [5]

Minea-Pic, A. (2020), “Innovating teachers’ professional learning through digital technologies”, *OECD Education Working Papers*, No. 237, OECD Publishing, Paris, https://doi.org/10.1787/3329fae9-en. [22]

Minea-Pic, A. (2020), *Innovating teachers’ professional learning through digital technologies*, OECD Publishing, Paris, https://doi.org/10.1787/3329fae9-en (accessed on 24 February 2021). [31]

Ministry of Science and Education (2023), *Rules on the advancement of teachers, professional associates and principals in primary and secondary schools and colleges*, https://www.zakon.hr/cms.htm?id=44746 (accessed on 13 April 2023). [30]

Ministry of Science and Education (2019), *Rulebook on rewarding teachers, teachers, professional associates and principals in primary and secondary schools and student dormitories*, https://narodne-novine.nn.hr/clanci/sluzbeni/2019_05_53_1019.html (accessed on 13 April 2023). [29]

Nusche, D. et al. (2016), *OECD Reviews of School Resources: Austria 2016*, OECD Reviews of School Resources, OECD Publishing, Paris, https://doi.org/10.1787/9789264256729-en. [41]

OECD (2023), *Advancing Digital Maturity in Croatia’s Higher Education System*, OECD Publishing, Paris, https://doi.org/10.1787/26169177. [8]

OECD (2021), “Teachers’ professional learning study: Diagnostic report for the Flemish Community of Belgium”, *OECD Education Policy Perspectives*, No. 31, OECD Publishing, Paris, https://doi.org/10.1787/7a6d6736-en. [39]

OECD (2020), “Learning remotely when schools close: How well are students and schools prepared? Insights from PISA”, *OECD Policy Responses to Coronavirus (COVID-19)*, OECD Publishing, Paris, https://doi.org/10.1787/3bfda1f7-en. [19]

OECD (2020), *PISA 2018 Results (Volume V): Effective Policies, Successful Schools*, PISA, OECD Publishing, Paris, https://doi.org/10.1787/ca768d40-en. [4]

OECD (2020), *Resourcing Higher Education: Challenges, Choices and Consequences*, OECD Publishing, https://doi.org/10.1787/735e1f44-en. [13]

OECD (2020), *Smart Data and Digital Technology in Education: AI, learning Analytics, and beyond*, https://www.oecd.org/fr/education/ceri/smart-data-digital-technology-education-learning-analytics-ai.htm. [6]

OECD (2020), *TALIS 2018 Results (Volume II): Teachers and School Leaders as Valued Professionals*, TALIS, OECD Publishing, Paris, https://doi.org/10.1787/19cf08df-en. [3]

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

OECD (2019), *PISA 2021 ICT Framework*, https://www.oecd.org/pisa/sitedocument/PISA-2021-ICT-Framework.pdf (accessed on 8 April 2022). [27]

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. [2]

OECD (2019), *Working and Learning Together: Rethinking Human Resource Policies for Schools*, OECD Reviews of School Resources, OECD Publishing, Paris, https://doi.org/10.1787/b7aaf050-en. [10]

Santiago, P. et al. (2016), *OECD Reviews of School Resources: Uruguay 2016*, OECD Reviews of School Resources, OECD Publishing, Paris, https://doi.org/10.1787/9789264265530-en. [43]

Santiago, P. et al. (2016), *OECD Reviews of School Resources: Slovak Republic 2015*, OECD Reviews of School Resources, OECD Publishing, Paris, https://doi.org/10.1787/9789264247567-en. [40]

Tømte, C. et al. (2019), “Digitalisation in higher education: mapping institutional approaches for teaching and learning”, *Quality in Higher Education*, Vol. 25/1, https://doi.org/10.1080/13538322.2019.1603611. [7]

Tynan, B., Y. Ryan and A. Lamont-Mills (2015), “Examining workload models in online and blended teaching”, *British Journal of Educational Technology*, Vol. 46/1, pp. 5-15, https://doi.org/10.1111/BJET.12111. [24]

University of Canterbury (2021), *Teaching Development Scholarships*, https://www.canterbury.ac.nz/about/ako/future-learning-and-development/academic-development/teaching-development-scholarship/ (accessed on 1 May 2021). [38]

University of Edinburgh (2017), *What is Scholarship of Teaching & Learning (SoTL)?*, https://www.ed.ac.uk/institute-academic-development/learning-teaching/staff/sotl/what-is-sotl (accessed on 1 May 2021). [37]

Wastiau, P. et al. (2013), "The use of ICT in education: A survey of schools in Europe", *European Journal of Education*, Vol. 48/1, pp. 11-27, https://doi.org/10.1111/EJED.12020. [28]

Watson, D. (2007), *The university and its communities*, https://www.oecd.org/site/imhe2006bis/37477605.pdf. [33]

Xu, D. and Y. Xu (2019), "The Promises and Limits of Online Higher Education UNDERSTANDING HOW DISTANCE EDUCATION AFFECTS ACCESS, COST, AND QUALITY". [25]

9 Monitoring and evaluation of digital education

This chapter discusses current challenges related to monitoring and evaluation of digital education, including the extent of penetration of digital technologies, their impact on learner outcomes, and the effectiveness of digital education policies. It also outlines some promising ways forward in building national monitoring and evaluation frameworks for digital education, including establishing frameworks linked to digital education strategies, and building on existing national evidence development activities.

Introduction

As explained at the outset of this report, digitalising education systems is not a goal in itself but it is a valuable tool than can help to enhance quality, equity and efficiency in education. Ensuring that digitalisation policies meet these needs requires information on the progress of education digitalisation and its impact on desired education outcomes. In this context, this chapter discusses how governments can best monitor the state of digitalisation in education and evaluate the effects of their policies across all dimensions of digital education.

For the purpose of this chapter, **monitoring** is understood as the systematic collection of performance data that can be used to track the progress of policies and the achievement of policy objectives in order to identify relevant system challenges and weaknesses. Policy **evaluation**, on the other hand, is the structured assessment of the design, implementation and results of a specific policy intervention and serves for the purpose of accountability and learning about the impact of individual policies (OECD, 2019[1]).

A well-designed monitoring and evaluation framework can act as a helpful guide for policy development and implementation on the use of digital technologies in education. Although countries may pursue different rationales or objectives in their digital education strategies (depending also on their education systems' state of digital development), a comprehensive monitoring and evaluation infrastructure that is aligned with a country's strategic vision for digitalisation is key to assess progress towards policy objectives and identify potential implementation challenges.

Substantial information gaps exist in national evidence infrastructures regarding the effective use of digital technologies in education, the presence of the necessary equipment, the human and institutional capacities for digital education and the extent of effective regulation of digital education. These information gaps have emerged for many reasons, including the relatively low policy priority attached to digitalisation in education systems until recently, the difficulty of arriving at a common understanding of and definitions related to digitalisation, and a lack of information on how users are integrating technology into teaching and learning processes (OECD, 2021[2]).

In the light of scarce information, this chapter examines a range of potential sources that governments could use to develop monitoring and evaluation infrastructures such as international indicators and institution-level external evaluation reports. It also highlights several ways in which governments can close information gaps and strengthen the evidence base around digital education. Some of the key questions on this issue that policy makers need to consider include:

- What information on the state of digitalisation is currently available along the different policy dimensions of digitalisation in education?
- How can governments take a systematic and holistic approach to monitoring and evaluation?
- Which existing sources of information could governments draw on to monitor education digitalisation and how can they close current data gaps?
- What is the state of evidence on the effectiveness of digitalisation and how might governments go about strengthening this evidence base?

Recent developments and current challenges

Significant information gaps persist on policy progress along most dimensions of digital education

A lack of information on spending on digital education undermines possible cost-benefit analysis

As observed in Chapter 5, little information is available at system level about the extent of investment in digital infrastructure in education. This is in part due to the inadequacy of current accounting and budgeting practices to track expenditure on digital education. These information gaps preclude attempts to link the benefits of digital education to its costs and thus undermine assessments of the efficiency gains derived from digital education. Improving data on investment in digitalisation is a necessary first step to understanding the value delivered by digital education, compared to its cost, but will likely require revisions to national and international accounting standards as well as national approaches to budgeting. Currently, international collaborative initiatives such as the OECD's Going Digital project are progressing with the necessary technical work to improve the identification of digital activities in statistical data in all sectors of the economy (OECD, 2022[3]).

While Internet connectivity is relatively well-monitored at system level…

One exception to the general lack of information on digital infrastructure relates to Internet connectivity. A policy focus on improving broadband access and connection speeds has led to the development of a range of indicators that measure progress on broadband roll-out and inequalities in connectivity (OECD, 2022[4]). NRENs also routinely monitor and provide information on the connectivity speeds to clients in different locations from their backbone. This means that information on Internet connectivity can be easily included in many national monitoring and evaluation frameworks.

… less is known about the availability and quality of digital equipment within education institutions

Unlike information on Internet connectivity, less data appears to be available at system level about the adequacy and quality (and to some extent the availability) of digital technologies in schools and higher education institutions, including their technical equipment and local area network capacity.

At the school level, there are some examples of data collections carried out by governments in order to assess the availability of digital infrastructure in the school system, and identify gaps:

- In **England (United Kingdom)**, a biennial Technology in Schools survey was recently launched to gather up-to-date data to understand the current state, use and spread of technology within primary and secondary schools in England and inform policy making. Findings from the first survey round will be launched in the summer of 2023.
- In 2021 **Utah (United States)** carried out the fourth iteration of its regular School Technology Inventory, which has run since 2015 and provides data on the stock and age of digital devices, hardware and software and teaching resources in every public school district and charter school across the state (UEN and Connected Nation, 2022[5]).
- The **Flemish Community of Belgium** also administers a sample-based survey (targeting about 20% of Flemish schools) to school leaders, teachers and students every five years, which focuses, among other topics, on digital infrastructure (European Commission/EACEA/Eurydice, 2019[6]) (Heymans et al., 2018[7]).

In addition to national surveys, international surveys can provide indications on digital equipment in schools:

- The European Commission's "2nd Survey of Schools: ICT in Education" administered in 2011/12 and 2017/18 provided country-level information on the access to digital infrastructure in schools based on interviews with school leaders, teachers, students and parents (European Commission, 2019[8]; European Commission, 2013[9]). In contrast to the Utah inventory, however, the survey was designed to yield country-level information, rather than to monitor the availability of technology in individual schools.
- The International Computer and Information Literacy Study (ICILS) also includes information on digital infrastructure in schools, although the central focus is on students' digital literacy (Fraillon et al., 2019[10]).
- With a broader country reach, OECD surveys such as TALIS or PISA can also provide useful perspectives on digital infrastructure since they ask school leaders about the adequacy of the digital infrastructure and the extent to which shortages or inadequacy of digital resources hinder the provision of quality instruction in their schools. TALIS also asks teachers about spending priorities for the education system, where one response category relates to digital infrastructure. While useful in identifying the presence of specific challenges related to the digital infrastructure, such data do not cover higher education, and their country coverage of the primary and upper secondary levels of education remains limited (OECD, 2022[11]) (OECD, 2019[12]) (OECD, 2020[13]).

At higher education level, there are only few examples of efforts to take stock of digital equipment, particularly in Europe. The long-running National Survey of e-learning and Information Technology in higher education institutions in the **United States** was first fielded in 1990 by the Campus Computing Project. While it does not directly collect data on infrastructure inventories, it elicits information on the categories of equipment on which technology budgets are spent, and perceptions of the quality of existing digital equipment (The Campus Computing Project, 2019[14]). In **Ireland**, a 2016 national review of higher education technical infrastructure aimed to develop evidence to support future digital development of higher education institutions, using the Campus Computing survey instrument (National Forum for the Enhancement of Teaching and Learning, 2016[15]). However, the survey was not repeated.

Along with the shortage of data on expenditure on digital technologies, a lack of information on inventories of digital equipment limits the capacity to plan for future public investment in digital infrastructure renewal. From an equity perspective, monitoring of digital equipment is also important to ensure that all students have beneficial exposure to tools that can help to build their digital skills or seize the benefits of digital education. Finally, given that ad-hoc research studies show mixed results regarding he relationship between the use of computers in an education setting and student outcomes (Bulman and Fairlie, 2016[16]), monitoring the availability, use and condition of digital equipment can help to structure and inform future research on its effects.

Research on the effective use of digital technologies in education is fragmented…

Many studies have been conducted on the impact, and to some extent on the cost-effectiveness, of digital technologies. As pointed out in Chapter 1, our understanding of the impact of digital education technologies has evolved as more rigorous research designs allowing causal inferences were developed and performed. While the number of rigorous studies has steadily increased and the COVID-19 pandemic has brought renewed interest and opportunities to examine the outcomes of digitally enhanced learning activities, there remains substantial scope to explore the mechanisms and uses that enable a positive effect of digital education technologies on student performance and other outcomes.

As shown in the Chapter 1, reviews of a range of studies of the effectiveness of digital education tools and methods show mixed results about their efficiency, quality and their impact on equity, across all levels of education. Information gaps and mixed results are particularly acute when it comes to measuring impact and efficiency gains, which are key to mobilise actors around digital education. In higher education, where evidence on the effectiveness of digital technologies does exist, it is often contradictory, and its robustness is undermined by methodological concerns, such as a lack of rigour in the study design (Cellini, 2021[17]; Bowen, 2012[18]).

Policy makers seeking to construct a monitoring and evaluation infrastructure must first commission or support research to review and broker existing evidence. Such efforts should aim to identify the different types of technology families and in particular, technology uses that have the most conclusive impact and that should thus be supported within education settings, and subsequently followed within a monitoring framework. More general investment in and funding of novel research focused on the use of digital technologies in education settings but also of innovative evaluation methods (e.g. that leverage the advantages offered by digital technologies for collecting and analysing data more rapidly) should accompany these efforts.

...and may not reflect the latest technological developments

In a fast-changing technology environment, evidence on the effectiveness of the usage of some smart technologies' risks becoming rapidly outdated (OECD, 2021[19]). This is a particular challenge, given the time lag involved in developing evidence: national and international survey instruments take years to develop, test, field and analyse. This concern is also reflected in the 2018 review of the PISA ICT background questionnaire which recognises the need to update and adapt questionnaires at each cycle, as the rapid evolution of technology may render some questions irrelevant very quickly. For example, the PISA 2018 background questionnaire contained items on students' use of portable music players, and memory sticks, technologies that had already been largely replaced by streaming music on smartphones and cloud storage of electronic files (Lorenceau, Maric and Mostafa, 2019[20]). To address the rapid obsolescence of questions, survey developers tend to phrase questions in broad and generic terms, which makes it more difficult to follow the take up of technologies at a very detailed and granular level.

The strong inertia of survey tools once evidence is collected is also an obstacle to capturing the latest technological developments. Indeed, once questions related to digital education are included in the questionnaire of a large-scale recurrent survey, policy makers of participating countries are typically interested in keeping them to allow for the monitoring of progress and trends over time. Accordingly, survey content often reflects a greater concern for trends than for relevance and coverage of emerging issues.

Likewise, many applications at the frontier of education technology are not yet established enough to permit definitive conclusions about the effectiveness in the teaching process or the viability of their use at scale. Survey instruments can only shed light on technologies after they have been adopted, rather than as they are emerging. If governments aim to have education stakeholders more deeply entwined in the improvement of education technology, then information is needed on emerging technologies as they are being established, not after they have been adopted (OECD, 2021[21]).

There is, therefore, a need for the co-existence of different monitoring tools to get an accurate picture of digital education take-up. Large-scale surveys are useful to monitor long-term trends, with the caveat that they may not always be reflecting the latest technological developments and their content needs to remain very general or shall quickly become obsolete. To address this issue, smaller-scale surveys more focused on emerging technologies, their take-up and impact can provide useful complements. However, they are by nature likely to be more volatile in terms of content areas and, as a result, less useful for monitoring trends over time.

Evidence on the capacity of institutions and education staff for digital education is more developed, at least at the school level

The many potential benefits of digital education (see Chapter 1) have provided impetus to a significant expansion of digital education infrastructure in schools and HEIs. However, as infrastructure barriers have been reduced and technological possibilities for digitally enhanced teaching have expanded, the digital competence of teachers, institutional leaders, administrators and their capacity to put these technological tools to use have emerged as central challenges (OECD, 2019[22]; OECD, 2021[23]). Schools' and teachers' capacity for digital education has thus emerged as a key enabling factor to ensure the wide adoption and spread of digital technologies in education, and to realise their full potential, as described in detail in Chapter 7. Accordingly, schools and teachers' capacity has been a strong area of focus for studies and surveys dealing with digital education.

Against this background, the first and second "European Surveys of Schools: ICT in Education" (ESSIE) have provided a formidable vehicle and a wealth of indicators to monitor developments and trends in relation to the spread of digital technologies in European school systems and teachers' digital education activities and engagement in professional development related to digital technologies (European Commission, 2019[8]; European Commission, 2013[9]).

Another key source of evidence in this area is the OECD Teaching and Learning International Survey (TALIS), which surveys teachers and school leaders from primary to upper secondary schools and, in an adapted format, early childhood education institutions. Among other topics, the use of ICT in teaching has been a consistent and growing area of focus for TALIS since its first round in 2008 (OECD, 2009[24]) (OECD, 2015[25]) (OECD, 2020[26]) (OECD, 2021[27]) (OECD, 2022[28]). TALIS' deliberate focus on teachers and their development makes it a natural vehicle for monitoring the existence of an enabling institutional and human infrastructure and the direct surveying of teachers and school leaders – rather than students – makes it a reliable source to assess training needs and capacity issues.

A number of other international surveys or assessments, including TIMSS, PIRLS, PISA and ICILS provide further data with some elements of digital education. Yet most of these existing international surveys or assessments – including TALIS – rely on teachers' (or school leaders') self-reports and perceived efficacy as a proxy for the actual digital education skills of teachers, and their schools' capacity for digital education. Evidence on educators' actual skills in integrating digital technologies in teaching is needed for a more accurate overview of capacity constraints.

Information on the status of data protection and cyber security related measures in schools is scarce

Chapter 4 discussed the growing cyber threats faced by education systems as well as the bigger responsibility digital education brings regarding protecting student data. While there have been some efforts to increase awareness of schools regarding these topics and inform the relevant players about necessary actions, little has been done to monitor the implementation of measures regarding cyber security and data protection.

With respect to cyber security, there are some examples of third-party reports on the state of risk exposure of schools. For instance, a report on "Cyber Security in schools" in the **United Kingdom** has recently been released by a collaboration between university, charity and private sector players (University of Kent, SWGfL and Bitdefender, 2022[29]). With respect to data protection, schools in OECD countries that are part of the European Union face strict reporting hierarchies as part of the GDPR. Schools have to appoint a Data Protection Officer who is responsible for reporting data breaches to the Information Commissioner's Office. Yet, there is no system-wide information available on implementation of data protection measures in schools.

Even where monitoring and evaluation is conducted, it is often focused on specific initiatives and programmes, rather than embedded in a systematic approach

Careful monitoring and evaluation are crucial for supporting innovation in the use of digital education technologies (Redecker et al., 2017[30]). In 2017, a Joint Research Centre review of the design of digital education policies in Europe acknowledged that the integration and innovative use of digital technologies in education had become a policy priority across Europe but found that most reforms either did not have an associated monitoring and evaluation process, or monitoring was tied only to the implementation of the specific programme. The recent UNESCO guidelines for ICT in education policies and masterplans also emphasise the importance of monitoring and evaluation and their role in enabling an iterative approach to policy making where the success of previous measures informs future decisions (UNESCO, 2022[31]).

Outside of evaluating specific policies during or immediately after their period of implementation, more systematic and persistent attempts to monitor and evaluate digitalisation are still rare, although more recent evidence shows promising developments in this area, at least for school education, as discussed later. Table 9.1 shows that while half of countries covered by a 2018/2019 review of digital education strategies in Europe carried out some form of monitoring and evaluation, few countries indicated that they conducted these activities regularly or had set a clear time frame (European Commission/EACEA/Eurydice, 2019[6]). However, information from an ad-hoc data collection performed by the OECD in September 2022 provides initial signs that some countries are now adopting more regular monitoring and evaluation as part of their strategies for digital education. Annex Table 9.B.1 provides a stock take of national monitoring and evaluation policies.

Overall, despite promising initiatives in some countries, most available data and evidence tends to be based on one-off research studies, or data collections that last only for the lifetime of a particular strategy and policy. There are few examples of recurrent data collections that permit countries to monitor trends or follow outcomes over time, or to use the data collected to model relationships between digital technologies and learning outcomes. The ad-hoc nature of monitoring and evaluation of digital education, often relying on different research designs, also tends to create conflicting evidence on its impact, and limits insight into which technology families and, most importantly, technology uses create the best impact for learners and should be facilitated by school practitioners and policy makers.

Further, monitoring appears more advanced in school education, compared to other levels. In higher education, most countries still face difficulties to systematically measure how much digitalisation is taking place, the ways digitalisation is unfolding and changing the practices of their staff and students, and the impact of digitalisation on higher education performance. The widely observed lack of system-level data on the digitalisation of higher education stems from several factors. These include, in particular:

- the low priority – until recently – placed by many governments on monitoring digitalisation in higher education
- the difficulty of defining digital higher education given the wide diversity of practices referred to by commonly used terms, such as “e-learning” or “digitally enhanced teaching and learning”, and the increasingly blurred line between different degrees of digitalisation as the use of at least some digital technologies for some higher education activities is now widespread
- the need for adequate, and potentially costly, data collection tools to help understand the practices and attitudes to technology of higher education students and staff

Table 9.1. Existence of monitoring and evaluation provisions for digital education across EU countries, 2018-19 and 2022

	Monitoring and evaluation	
	Monitoring and/or evaluation of digital education strategies and policies carried out in the last five years by top-level authorities 2018-2019	Existence of monitoring and evaluation provisions for top-level strategies of digital education 2022
Data collection source Countries/economies	(European Commission/EACEA/Eurydice, 2019[6])	OECD[1]
Austria[C]	Yes (ad-hoc)	Yes
Belgium FL	Yes (regular)	Yes
FR[C]	No	No
GE[C]	No	No
Bulgaria[C]	Yes (regular)	Yes
Czech Republic[C]	Yes (regular)	Missing
Cyprus	No	Missing
Croatia[C]	Yes (ad-hoc)	Yes
Denmark[C]	Yes (ad-hoc)	No
Estonia[C]	Yes (regular)	Yes
Finland[C]	Yes (ad-hoc)	Missing
France	Yes (ad-hoc)	Yes
Germany[C]	Yes (ad-hoc)	Yes
Greece	No	Missing
Hungary[C]	No	Missing
Ireland	Yes (ad-hoc)	Yes
Italy[C]	Yes (ad-hoc)	Yes
Latvia[C]	No	Yes
Lithuania[C]	No	Yes
Luxembourg	No	Missing
Malta	No	Missing
Netherlands	Yes (ad-hoc)	No
Poland	Yes (ad-hoc)	Missing
Portugal[C]	No	Yes
Romania[C]	Yes (ad-hoc)	No
Slovak Republic[C]	No	Yes
Slovenia	Yes (ad-hoc)	Missing
Spain[C]	No	Yes
Sweden[C]	Yes (regular)	Yes

Note: Information from 2019 was taken from the Eurydice report on 'Digital education at School in Europe'. To update this information, the OECD reached out to the national officials in the Eurydice country units of all EU member states in 2022 and conducted background research on their digital education strategies. Superscript ''C'' in the country column indicates that the information displayed was obtained from national officials. Further information to contextualise the monitoring and evaluation provisions in 2022 is provided in Annex 9.B

Source: Eurydice (2019[6]), Digital Education at School in Europe, Eurydice Report. Luxembourg: Publications Office of the European Union, https://eacea.ec.europa.eu/national-policies/eurydice/content/digital-education-school-europe_en (Accessed on 10 September 2022) and OECD data gathering.

Promising approaches for monitoring and evaluating digital education

There are multiple possibilities for creating a monitoring and evaluation infrastructure for digital education

A key conclusion of Chapter 2 is that the policy ecosystem for high-performing digital education should be centred on a strategic vision; should include mechanisms for effective coordination across policies; and should include feedback loops to permit revision of the strategy. At a national level, this vision is best achieved through a process of systematic monitoring of progress and possible implementation challenges, and wide consultation to agree on the elements of the monitoring framework (OECD, 2013[32]). It also requires improvements in the supply of high-quality data and evidence sources to make the case for reform at the vision-setting stage, and greater efforts to institutionalise monitoring and evaluation practices later on to track progress against the objectives outlined in the digital education strategy.

In the interest of efficiency, national governments can initially assess and draw upon existing national and international frameworks and data sources to monitor and evaluate the implementation of their digital education policies (UNESCO, 2022[31]). These may include administrative data, surveys of student or teacher experiences and perceptions, promotion of institutional self-evaluation frameworks to support self-reflection and improvement of institution-level digital strategies, a digital focus of quality assurance evaluation processes, research projects and findings, and the adoption of frameworks to measure the digital competence of educators.

However, as discussed above, there are substantial gaps in national and international data ecosystems that limit the extent to which investment, use and impact of digitalisation can be measured, monitored or evaluated. In turn, this limits countries' ability to develop a coherent monitoring and evaluation infrastructure for digitalisation across education systems. A smart mobilisation of existing evidence can already help countries assess the state of the digital maturity of their education institutions against objectives or benchmark their own performance against international education systems. However, many of the gaps will only be filled through new data development or the mobilisation of new sources of data/evidence (e.g. big data).

Thus, creating a comprehensive monitoring and evaluation framework may comprise the adaptation of existing data collection frameworks, the design and development of original data collections and the mobilisation of novel sources of data/evidence. Collection of novel empirical data to inform all elements of digitalisation in education is a demanding prospect, requiring multi-year development processes and substantial financial and human resources, which creates a burden on data providers (e.g. survey respondents or administrators preparing data submissions). A realistic monitoring and evaluation framework will need to account for resource constraints and the reporting burden placed on institutions, and thus use or adapt existing data resources as much as possible, carefully balancing the benefits of new data collections with its associated administrative and financial costs.

Develop a national framework for monitoring and evaluating digital education…

The measurement of the range of activities that comprise the 'digital economy' is an emerging area of policy concern across all economic and social sectors. Many such activities have focused on assessing the extent of adoption of digital technologies in private business and industry. However, there is an increasing impetus on governments to monitor the social impact of digital technologies, and the extent to which digitalisation is supporting social goals and transforming government services (OECD, 2020[33]). Measurements related to education and skills are often considered as foundational enabling factors for all digital policy dimensions. At the same time, education-related indicators integrated into wider digitalisation monitoring frameworks tend to focus on the supply of human capital for labour markets and the wider economy. To date, little emphasis has been placed on systematically measuring and monitoring digitalisation within the education sector.

However, policy makers are increasingly aware of the need to measure digitalisation within their education systems to ensure accountability and enable evidence-driven policy making. In schools, a growing number of education systems work on developing a stronger evidence base on the penetration and impact of digital education, and evaluate the effectiveness of different digital pedagogical approaches, learning resources or tools. These new initiatives are often linked to the creation of digital education strategies. For example:

- The Schools Digital Strategy of **New South Wales (Australia)** provides an example of a comprehensive and co-ordinated digital education strategy that puts forward a vision for digital education, and proposed actions co-designed between the government, school leaders, teachers and parents. The digital strategy also acknowledges the need to track outcomes, by measuring how schools are improving their digital maturity, and to gauge the most effective approaches to digital education. To do so, the strategy envisions facilitating access to education data by policy makers to analyse which digital pedagogies, teaching resources, learning approaches, tools and techniques deliver the best learning outcomes (Department of Education, Australia NSW, n.d.[34]).
- In **Italy**, the 2022 School Digitalisation Plan "*Piano Scuola 4.0*" foresees the implementation of two key actions: 'next generation classrooms' and 'next generation labs'. While the prior project concerns the creation of a digital learning environment in classrooms, the latter focuses on strengthening students' skills in areas as robotics, AI or coding. Implementing schools will undergo monitoring activities every 6 months that include the collection of qualitative and quantitative data on the progress of the implementation, outputs, and outcomes of the projects. These data points will be compared against schools' performance on the national evaluation system and will be published on an online dashboard (Ministry of Education Italy, 2022[35]).
- The pilot national e-Schools digitalisation project in **Croatia** developed a concept of "levels" of digital maturity. The levels are intended to indicate the initial extent of maturity in schools, monitor their progress as investments were made in digital technologies (including network connectivity, laptops and educational software), and provide a generic assessment of the outcomes of the project in terms of schools' increase in digital maturity (Balaban, Begicevic Redjep and Klacmer Calopa, 2018[36]). The pilot project covered 151 schools, and evaluations indicated that most schools raised their digital maturity by at least one level as a result of the pilot, and that pilot schools were able to pivot quickly to remote instruction during the COVID-19 pandemic. A second phase of the project, covering all schools in Croatia, is currently underway, and includes an expanded education programme for the development of staff digital competences (Centre for Applied Psychology at the Faculty of Philosophy in Rijeka, 2018[37]).
- In April 2022, **Ireland** launched a revised Digital Strategy for Schools. The strategy is accompanied by Implementation Plans. The first plan will run from 2022-2024 and is intended to develop appropriate oversight and measurement processes and procedures to provide for effective implementation of the strategy. These sources of evidence will inform a midterm review at the end of the first phase, and the next Implementation Plan from 2025-2027 (Ireland, 2022[38]).

There are also some examples of nascent national efforts to monitor digitalisation in higher education systems. For example, recent OECD and EC collaboration with Hungary focused on efforts to define indicators on digitalisation in higher education (OECD, 2021[2]). Similarly, a recent OECD-EC project in Croatia examined the digital maturity of higher education institutions using quantitative and qualitative means (OECD, 2023[39]).

The creation of a national monitoring and evaluation infrastructure for digitalisation in education will require careful consideration and long-term investment in its incremental development. Prior to developing a monitoring framework, national discussions and consultations will be needed to define the specific elements of digitalisation that should be monitored or evaluated, as well as other operational elements like the periodicity of monitoring processes and the assignment of resources to a monitoring and evaluation function. Based on recent OECD recommendations for building capacity for evidence development and policy monitoring (OECD, 2021[40]; OECD, 2020[41]), important steps in the process may include:

- Mapping of existing national and international data and evidence, and raising awareness of current available sources of information with stakeholders
- Together with stakeholders, undertaking systematic identification of current evidence gaps and likely future information needs, taking into account policy objectives
- Establish, ideally through consensus, an agreed list of indicators that should be tracked within a national monitoring and evaluation framework, taking into account existing data availability, the importance of the signal provided by the indicator, and the need for parsimony in a context of finite resources
- Evaluation of organisational capacities to design, develop, contribute to, and disseminate new data and evidence gathering initiatives
- Agreement on roles and responsibilities within the system for the monitoring and evaluation framework, including evidence gathering, processing and dissemination.

Consider new data development initiatives to systematically monitor the state of digitalisation in education systems

A national monitoring and evaluation framework should also ideally promote new data development related to the state of digitalisation across all sectors of education, including schools, higher education institutions, vocational and adult learning providers.

- **Austria** provides a recent example of a national effort to develop a holistic education monitoring system (EMS), as a basis to assess the impact of policy actions and subsequently adjust policies and implementation. The development followed a stepwise process, first defining goals of the framework, then, incorporating stakeholder engagement, developing an "indicator monitoring plan". The final step entailed the development of a technical solution to bring together data from disparate sources into the monitoring framework. An OECD analysis found that the EMS design could be further improved by: articulating how the information in the framework should feed into the improvement of learning outcomes; building a stronger data culture; focusing on securing resources at the planning stage, and ensuring that the efforts to develop the framework are compatible and complementary to other ongoing and planned policy initiatives (OECD, 2021[40]).
- **Japan** has also recognised the importance of integrating data more profoundly into education systems, as part of its objective to create "a society where anybody, at any time and place, can learn with anybody in his/her own way". Following widespread consultation, public authorities have created a roadmap for digitalisation which envisages providing a "big picture" of data in education, through bringing together, enhancing and standardising existing data sources (for example, by adopting international standards into national data frameworks). The first stage of the roadmap entails moving education institutions' administrative processes procedures and data collections online as much as possible. A second stage envisages using the online platforms built in stage one as a basis to collect and analyse log data from learner devices that can feed into multi-dimensional monitoring and evaluation processes. A third stage could begin to use the data collected to support individually optimised learning and to evaluate progress on academic achievement and non-cognitive skills. The roadmap plan is intended to cover all aspects of the Japanese education system (Digital Agency et al., 2022[42]).
- **Estonia** is another example of a country that has adopted a comprehensive approach to the monitoring and evaluation of its digital education progress. Digital education (with a focus on the digital competences of learners and teachers, digital solutions and learning environments) is

addressed as part of a broader lifelong learning strategy implemented through 3-year programmes and monitored annually based on a set of indicators. Further, schools are advised to structure their internal evaluations on activity indicators, among which the frequency of digital technology use in learning and teaching. In addition, Estonia has piloted a low-stake test of students' digital competences as part of quality assurance procedures. Previous evidence showed that the country also relied on schools' self-reporting on their digital technology infrastructure, surveys of students, teachers and parents in Estonian schools, as well as an annual report developed by a specialised agency (European Commission/EACEA/Eurydice, 2019[6]). More generally, the strength of the Estonian monitoring and evaluation system lies in the Estonian Education Information System (EHIS) as Estonia has established and maintains a digital, online and encompassing information system that brings together data on schools, pupils, teachers, exams and qualifications (OECD, 2020[43]). The accuracy of the data (due to live data collection), its structure (enabling very fine analyses), the possibility of connecting it to other national databases and its accessibility to the wider public (through the online platform Educational Eye) are among the main strengths of EHIS. Overall, the case of Estonia shows how well-developed information systems contribute to successful digital education governance and policy making (OECD, 2020[43]).

- **Portugal** can also provide a source of inspiration as a country that is leapfrogging its digital transformation (Estevez et al., 2021[44]). Digital education is embedded within a broader digital transformation strategy which is linked to a comprehensive action plan. (Portugal, 2020[45]). In order to ensure the proper monitoring of the set of programmes and initiatives of the action plan, a monitoring framework was developed, based on a list of about 100 indicators, and in education, an Observatory for Digital Competences, has developed a comprehensive indicator framework measuring trends over time for the selected indicators (Direcao-general de estatisticas de educacao de ciencia, 2020[46]). Further, Portugal launched an online platform in the end of 2021 to report the progress of school digitalisation and to allow continuous data collection. The data is entered into the system by digital ambassadors who work directly with schools in supporting and monitoring digitalisation. The platform was launched at the beginning of 2022 and has already been used to collect data on the status of teacher training and the digital development of schools which is shared publicly on an online dashboard (República Portuguesa, n.d.[47]).

Connect monitoring initiatives to the national vision for digital education and take into account broader social goals connected to digitalisation

Ideally, monitoring and evaluation of digitalisation in education should be based on a national strategic vision of the role that digitalisation should play in education systems, and its intended impact. Indeed, a shared vision on goals can provide a strong foundation for the identification of relevant performance targets and potential indicators for monitoring and performance evaluation, as the examples from **Portugal** or **Ireland** illustrate.

The analytical framework presented in Chapter 1 can also serve as a foundation for monitoring and evaluation. It provides a broad, comprehensive and systematic overview of dimensions along which progress in digitalisation can be measured. These dimensions are:

- the effective use of digital technologies through adequate pedagogies, curricula and assessment frameworks
- the presence of the necessary guidance and a regulatory framework for digital education
- the adequacy of funding and procurement mechanisms for digital education
- the availability of accessible, innovative and high-quality infrastructure for digital education
- the capacity of educators, institutions and at a system level to engage in digital education

- the extent to which human resource policies incentivise and empower educators' effective use of digital technologies.

The impact of policy reforms along these dimensions should then be assessed in terms of access and equity, quality and efficiency.

In progressing with the development of a monitoring and evaluation framework for digital education, governments also need to bear in mind the broader context for the monitoring of digitalisation more generally, and account for the priorities for measurement of the wider digital economy outlined in the OECD's Going Digital Roadmap (OECD, 2022[3]), namely:

- Making the digital economy visible in national accounts/statistics
- Understand the impact of digital transformation
- Encouraging measurement of the impact on social goals and well-being
- Design new and interdisciplinary approaches to data collection
- Monitor emerging technologies
- Improve measurement of data and data flows
- Define and measure skills
- Measure trust in online environments.

In operationalising the monitoring and evaluation framework, attention should also be paid to minimising response burden. A national monitoring framework should thus as much as possible take existing data and indicators as its starting point, where they exist, and expand, where possible, through modification of existing data collections. The next section discusses the possibilities of leveraging and building on existing national and international evidence development activities for the purposes of monitoring and evaluating digital education.

Leverage and build on existing sources of evidence for the development of national monitoring and evaluation infrastructures

A national monitoring and evaluation framework can draw upon several evidence streams, as described below. Strategies for building an evidence infrastructure for digital education can include adding a "digitalisation lens" to current national administrative and statistical data collections, expanding and repeating previous one-off surveys, incorporating internationally comparative indicators, and making greater use of qualitative sources of evidence, such as quality evaluation reports and the results of research studies.

Add a "digitalisation lens" to national administrative and statistical data collections where possible

Administrative data systems, such as student information systems, are widely used by education institutions, and most governments impose common reporting requirements on public and government-dependent private institutions to monitor their activities. These data points are fed into the production of official statistics and passed on to international organisations such as the UNESCO/OECD/EUROSTAT annual data collections. As governments advance on strategic objectives related to digitalisation in education, evidence on some forms of digitalisation may be collected through adaptation of these existing data collections.

The Integrated Post-Secondary Education Data System (IPEDS) in the **United States** offers an example of how an administrative data collection can be adapted to support indicator frameworks on digitalisation. The IPEDS is a national database on post-secondary institutions in the United States, maintained by the National Center for Education Statistics, part of the United States' Department of Education Institute of

Education Sciences. All public and private institutions (including higher education institutions and many vocational education providers) that receive federal funding are required by law to report their administrative data to IPEDS in aggregate form. Because of its coverage, IPEDS data may be used to generate both institution and system-level indicators related to digitalisation, and to model the relationship between the extent of digitalisation and other institution-level indicators. For example, IPEDS collects data from each institution on their "distance education" activities, defined as "education that uses one or more types of technology to deliver instruction to students who are separated from the instructor and to support regular and substantive interaction between the students and the instructor synchronously or asynchronously" (NCES, 2021[48]).

Table 9.2 shows the items collected as part of the IPEDS annual survey that can be used to routinely monitor students' enrolments and graduations by mode of delivery, and the extent to which institutions are offering programmes through distance education. In addition to distance education data, IPEDS collects data on institutions' digital/electronic library resources, including the number of digital/online books, databases, media, and serials. These latter variables could also be used to develop useful measures of the digital infrastructure of institutions.

Table 9.2. Overview of distance education data items collected annually in IPEDS

Indicator	Data coverage period	Description
Institutional Characteristics (IC)	Current Academic Year	Captures whether institutions offer distance education courses and/or programmes for undergraduate and graduate students and whether all programmes are offered exclusively via distance education
12-Month Enrolment	July 1-June 30 (prior Year)	Captures the number of students enrolled in distance education courses over 12-month period
Fall Enrolment	Institutions' official fall reporting period	Captures the number of students enrolled in distance education courses in the fall term and, of the students enrolled exclusively via distance education, the number in various geographic categories
Completions	July 1-June 30 (prior year)	Captures whether all, some, or none of the programmes (organised by field of study) and award level can be completed entirely, via distance education, and whether certain distance education programs have on-site components

Source: National Center for Education Statistics (n.d.[49]), Distance Education in IPEDS. US Department of Education, Available from: https://nces.ed.gov/ipeds/use-the-data/distance-education-in-ipeds

As well as the United States, some other governments across OECD countries have also started to collect data on participation in higher education by mode of delivery:

- In **Australia**, higher education institutions are required to report data on students according to their mode of attendance, classifying them as internal (i.e. campus-based), external (i.e. fully at a distance) or multi-modal (i.e. hybrid education).
- In the **United Kingdom**, the Higher Education Statistics Agency collects data on the mode of study of students enrolled on degree programs and their domicile (United Kingdom or abroad) (HESA, 2020[50]).

A major limitation of IPEDS and some other administrative reporting frameworks is the fact that data is reported only at the institution level. Student-level reporting can substantially increase capacity for monitoring student outcomes according to the mode of delivery of the programmes they are following (Miller and Shedd, 2019[51]). Student-level reporting also opens the possibility of constructing panel data to track and compare the outcomes of students exposed to different patterns of usage of technology. The

Integrated Data Infrastructure in **New Zealand** offers an example of the substantial analytical potential of anonymised individual student records, when linked to other databases such as labour market or social protection records (Jones et al., 2022[52]). The inclusion of a variable for extramural (off-campus) and intramural (on-campus) study allows New Zealand authorities to conduct in-depth analysis of the characteristics and outcomes of students according to their mode of study (Ministry of Education, 2014[53]).

At school level, distance enrolments are less common than in higher education, hence there is less of a need to monitor school participation by mode of delivery. Notwithstanding this, several countries' education monitoring information systems collect data from individual institutions – or for each student, see below – that can be harnessed to generate information on some aspects of digital education.

- As described previously, **Estonia** has successfully organised its Estonian Education Information System (EHIS) around the individual student, by bringing together different databases on important parts of the education system such as schools, pupils, teachers, exams and qualifications. Its main challenge though is to foster the use of its rich data by schools to promote evidence-based decision-making (OECD, 2020[43]).
- Individual level data was also used – although not as part of a country-wide education monitoring information system – to assess the impact of the "e-schools" project in **Croatia**. The Centre for Applied Psychology at the Faculty of Philosophy in Rijeka conducted a study during the pilot phase of the project focusing on individual level results such as learning outcomes, digital competences, and attitudes towards digital technologies of students and teachers. The study included comparisons of treated and non-treated observations as well as of observations of the same individual before and after the intervention. Data was collected through online questionnaires and digital competence tests (Centre for Applied Psychology at the Faculty of Philosophy in Rijeka, 2018[37]).

Consider expanding and repeating existing national data collections on digitalisation in education

As indicated earlier in this chapter, there are few examples of efforts to monitor digitalisation across education systems. At the same time, there have been national studies in some countries that could be updated and repeated (wherever they are not already administered on a regular basis) to strengthen the national monitoring and evaluation infrastructure.

One of the most comprehensive systemic studies of digitalisation in education was carried out in **Germany** by the Bertelsmann foundation in 2016/2017. The study has a significant scope, drawing on representative samples from four different education sectors (adult education, vocational education, schools and higher education) across Germany. The study is also distinguished by its focus on the users and usage of technology, rather than on infrastructure. Microdata from the survey were also made available through the German social science data archive, allowing researchers to conduct secondary analysis. However, the study has not been repeated since its first edition (Bertelsmann Siftung, n.d.[54]).

Further, national data collection initiatives touching upon digital education issues can be harnessed to collect information on digital technologies used by schools. This is for instance the case for national surveys implemented in **Denmark**, **Estonia**, the **Flemish Community of Belgium** or **Italy** as described above (European Commission/EACEA/Eurydice, 2019[6]). In **New Zealand**, the Council for Education Research also conducts a survey of its secondary schools every three years, which includes a brief section on teaching and learning with digital technology (Bonne and MacDonald, 2019[55]).

Repetition of national data collections of digital education can also support responding institutions to keep statistical and reporting needs in mind when organising internal information and data flows. **Canada's** Digital Learning Research Association commenced an annual National Survey of Online and Digital Learning in Canada's publicly funded post-secondary institutions in 2017. The regular nature of the survey has encouraged higher education institutions to improve their internal tracking of activities to ensure they can more easily report the required information.

In **Ireland**, the National Forum for the Enhancement of Teaching and Learning, supported by government funding, developed a comprehensive national survey of digital experiences in higher education, with strong involvement of higher education stakeholders in its design and implementation. The Irish National Digital Experience Survey (INDEx) drew responses from more than 30 000 students, teachers, librarians and others across the system, and led to the creation of indicators that assess digital readiness, digital practices and digital performance. Notably, INDEx was adapted from an existing higher education survey used to varying extents in the United Kingdom, New Zealand and Australia – the Digital Experience Insights survey, developed and provided by the UK NREN Jisc.

Every five years, the **Flemish Community of Belgium** publishes a study on ICT integration in Flemish education "MICTIVO", based on the results of a web survey conducted in 20% of Flemish schools which gathers the views of school leaders, teachers and students. MICTIVO focuses on four components: infrastructure and policy, perceptions, competences and usage at the micro level, measured through scales derived from exploratory and confirmatory factor analysis (Heymans et al., 2018[7]).

Within individual education systems, many ad-hoc surveys of student and teacher perceptions have been carried out, especially during the COVID-19 pandemic. Due to the specific emergency context of the pandemic, the results of most of these surveys may not have wider applicability/validity. Depending on the specific survey design and development process, such surveys may potentially be repeated or adopted into recurrent surveys of higher education students or staff, fielded either nationally or internationally (for example, through the Eurostudent survey instrument). Examples of recent national or international survey initiatives include:

- In **Hungary**, the Ministry for Innovation and Technology commissioned two surveys on digital higher education in 2020, administered by the Digital Higher Education Competence Centre. A first survey sought information on digital practices and institutional leaders' views on factors determining the extent of digitalisation in their organisations, including external factors (e.g. students' digital skills) and internal factors (e.g. access to digital infrastructure at an HEI, teachers' digital skills, etc.). A second survey collected data on access to digital infrastructure at Hungarian HEIs, including high-speed Internet access and the availability of digital tools.
- The **European Students Union** carried out a survey of student experiences during the COVID-19 lockdown, which included questions about access to hardware, software and connectivity, students' perception of the advantages and disadvantages of online learning, and students' perception of their digital capabilities.

Aim to integrate relevant international indicators into national monitoring and evaluation frameworks

Countries are increasingly interested in comparing their performance on digitalisation with other countries, as part of national monitoring and evaluation efforts (Trucano, 2019[56]). Three distinct categories of international indicators are available: general digitalisation performance indicators, policy indicators, and international surveys or assessments that have elements relevant for digitalisation. Each of these are discussed in turn below.

General indicators of digital performance

Digitalisation is an engine for economic growth, job creation and social connectivity. As such, digital innovation is now a central pillar of all areas of government policy. As the digital economy is growing, a range of measurement frameworks have emerged, aiming to give greater visibility to digital aspects of various economic sectors and the impact of digitalisation (OECD, 2022[3]).

Most existing measurement frameworks aim to assess progress on digitalisation across a broad range of economic and social sectors (Table 9.3). A common approach is to develop composite performance indices based on a range of indicators. Some monitoring tools operate on a global scale. For example, the Network Readiness Index by the Portulans Institute ranks 130 global economies on technology development and the ability of countries to capitalise on digital opportunities. It is a composite index based on four primary pillars: technology, people, government and impact. The World Digital Competitiveness Ranking of the International Institute for Management Development measures the capacity of 64 economies on their adoption of digital technologies for transforming government practices, business models and society in general (Portulans Institute, 2021[57]).

In Europe, prominent examples of digitalisation monitoring tools include the European Union's Digital Economy and Society Index (DESI) – a composite index that monitors broadband connectivity; human capital for digitalisation; integration of digital technology; and digital public services (European Commission, 2022[58]). Another example of a European framework is the Centre for European Studies' Index of Readiness for Digital Lifelong Learning (IRDLL) which measures three key dimensions: 1) learning participation and outcomes, 2) institutions and policies for digital learning and 3) availability of digital learning (CEPS, 2020[59]).

Table 9.3. Selected international monitoring tools for general digital performance

Name of the Monitoring Tool	Description	Country coverage and periodicity.
Digital Economy and Society Index (DESI), based on DigComp	4 key dimensions, covering 37 indicators: 1) human capital (internet user skills and advanced skills); 2) connectivity (fixed broadband take-up, fixed broadband coverage, mobile broadband and cost); 3) integration of digital tech (business digitisation and commerce); 4) digital public services (e-government); 5) use of internet services (citizen's usage of internet services and online transactions) - dropped in 2021	EU countries Annual publication since 2014
Institute of Management Development (IMD) World Digital Competitiveness Ranking (WDC)	4 principal dimensions, covering 334 sub-indicators: 1) economic performance (domestic economy and employment) 2) government efficiency (public finance and societal framework); 3) business efficiency (labour market and productivity); 4) infrastructure (education and technological and scientific infrastructure)	64 world economies Annual publication since 1989
Centre for the European Policy Studies' Index of Digital Readiness for Lifelong Learning (IRLL)	This study was carried out as a collaboration between the Centre for European Policy Studies and Grow with Google, and combines conventional indicators with alternative data sources, such as indicators of expert consensus and data from internet searches. It has 3 primary pillars: 1) individual learning outcomes; 2) institutions and policies for digital learning; 3) availability of digital learning	27 EU member states Published in 2019
Portulans Institute - Network Readiness Index (NRI) 3rd edition	4 key dimensions that make up a composite index: 1) technology (access, content and future tech); 2) people (individuals, business, government); 3) governance (trust, regulation, inclusion); 4) impact (economy, quality of life, SDG contributions)	130 global economies Published annually since 2019 (Portulans took over the index from the World Economic Forum in 2019)

Source: Author's elaborations

In addition to these existing indicators of digital readiness/performance, the World Bank has developed an Edtech Readiness Index (ETRI) which aims to go beyond measuring the availability of devices and the level of connectivity to capture key elements of the larger education-technology ecosystem in a country. The index is organised around six pillars: the first three pillars focus on the actors in the education system (school management, teachers, students), and the last three examine the inputs and infrastructure that the actors need to use EdTech (devices, connectivity, digital resources). For each pillar, the ETRI reports on a practice indicator (to capture the practices at the school level), a de jure policy indicator (to capture whether there is a policy to inform each practice), and a de facto policy indicator (to measure the extent to which the policy is implemented). The ETRI has started to pilot in 2022 with the first surveys already having been conducted in Ho Chi Minh City (Vietnam) (Venegas Marin et al., 2021[60]; Hu'o'ng, 2022[61]). It could thus provide an additional source of evidence in the future on the readiness of various school systems for digital education.

Comparative policy indicators

As well as integrating comparative indicators of performance, policy makers are also interested in comparing their policy frameworks and progress on the digital transformation of education with those of other countries, as a means of comprehending to what extent national policies are aligned with international best practices.

International policy surveys have become more prevalent in recent years. Indeed, many countries contribute information about the characteristics of their education systems and recent reforms to international initiatives such as the Eurydice comparison of education systems (Eurydice, 2022[62]) and the OECD Education Policy Outlook (OECD, 2018[63]). Such surveys provide useful information for countries wishing to learn about reforms in other jurisdictions, or to get a snapshot overview of how their policy framework compares with that of other systems. But in general, policy surveys are not carried out on a regular and recurring basis, limiting their suitability for inclusion in a monitoring framework. Therefore, integrating comparative policy indicators into monitoring frameworks would require new surveys to be designed, or existing qualitative data collections to be adapted and/or repeated.

With these caveats in mind, on the issue of digitalisation of education more specifically, the European Commission, in collaboration with the European Education and Culture Executive Agency and Eurydice, undertook a review of its member states' digital education state of play and policies in 2018/19 prior to the pandemic (European Commission/EACEA/Eurydice, 2019[6]). In the context of preparing this report, the OECD has worked on updating some of its elements as presented in Chapter 2.

Going beyond the European policy landscape, the OECD Centre for Education Research and Innovation (CERI) is currently collecting qualitative information across OECD countries about the governance of digital education and public-private relations between governments and the industry for educational technology in primary, lower secondary and upper secondary levels of education, including secondary VET. This policy survey is gathering responses from central, state/regional, and local authorities. Currently 26 countries (among which 18 EU countries) have responded or confirmed to respond to the survey. Results from the OECD CERI survey will be released in 2023. In addition, a fixed-response OECD Higher Education Policy Survey was fielded in 2022, collecting evidence on digitalisation at the tertiary level (Box 9.1). Comparative information on digitalisation policies in education will also be collected as part of a new OECD project on "Resourcing school education for the digital age – effective digitalisation and future-ready teachers".

Box 9.1. Policy indices and the OECD Higher Education Policy Survey

Cross-national indicators that monitor progress on digitalisation in higher education systems have yet to be developed. However, international policy surveys can provide some comparative information on how well the policy environment is adapted to the development of effective digital technologies in higher education systems. For example, the OECD Higher Education Policy Survey is a fixed-response survey instrument used to collect comparative data on higher education policies across OECD member states (and partner countries, candidate OECD members, and other EU members). The 2022 edition of the survey focused partially on digitalisation policies, establishing a baseline set of comparative data on regulation and governance of digitalised higher education and financial and human resources available for digitalisation. Comparative country data based on the survey will be published in 2023.

Fixed-response policy surveys could be a useful vehicle to monitor the policy environment for digital education. The fixed nature of the items limits the cost of participation for responding jurisdictions, and the resulting dataset can be used in many ways to provide insights into policy frameworks governing digitalisation in higher education. For example, there is increasing interest in indices that can be used to monitor and benchmark policy implementation in emerging areas of national and international importance. Recent example of such indices include the SME Policy Index (OECD et al., 2020[64]) and the OECD Digital Government Index (OECD, 2020[65]). The Higher Education Policy Survey data is suitable for the construction of such indices. For example, an index of "*policy support for improving digital pedagogy*" might be constructed out of responses to questions about academic workload policies and support for professional development, while an index of "*support for digital learners"* might be constructed out of items on policies with respect to student grant and loan support, virtual student services, and connectivity and hardware support for students.

In future years, questions from the OECD Higher Education Policy Survey on digitalisation could be repeated in order to assess the evolution of policies and monitor trends, extended to cover digitalisation policies concerning other levels of education, and data coverage strengthened through partnership with other international organisations.

International surveys or assessment indicators

A range of international large-scale surveys or student assessments provide other promising sources of evidence for the development of monitoring frameworks on digital education. Indeed, a number of international surveys gather data at various levels of school education, and as they are typically repeated at regular intervals and built on representative samples of respondents, they can provide a valuable source of evidence coming from practitioners on the ground, while yielding estimates of various indicators at the system level.

Large-scale surveys and assessments offer a range of benefits to participating education systems. First of all, the development of the instruments (questionnaires/tests) generates economies of scale as the development costs are shared between a large number of participants. Therefore, they tend to be more cost-effective to develop than national surveys. Secondly, large-scale surveys and assessments harness expertise from around the world, pooling highly specialised expertise in large consortia and having the survey instruments reviewed by experts from multiple countries to foster their validity. Thirdly, they yield internationally comparative indicators which allow countries to not only monitor progress over time, but also get a sense of their state of digital maturity relative to peer education systems.

Yet, large-scale international surveys and assessments also involve constraints, as their repetition over time leads to some inertia in the survey/test content to capture trends over time. They also involve extensive negotiations among countries on the survey focus, and countries may not be able to monitor all aspects of interest to them – although there is usually some flexibility for some country-specific questions. Lastly, these surveys can be higher stakes than national surveys given the development of comparative data – with the risk of ranking interpretation – and typically very strict technical standards which can lead to non-adjudication of the data if a country fails to meet sufficient response rates for instance.

Depending on their nature – survey or assessment – and their target population for sampling – students or teachers – these survey tools will be more or less useful to policy makers in monitoring policies and progress. For instance, policy makers interested in advancing equity goals will be interested in indicators expressed in terms of the percentage of students benefitting from quality digital resources or infrastructure, or on the contrary suffering from shortages in these areas. This is the sampling approach followed by the European Survey of Schools ICT as well as all student assessments (PIRLS, TIMSS, PISA, ICILS). By contrast, policy makers monitoring progress in infrastructure upgrades or capacity building programmes will be more interested in indicators expressed in terms of the percentage of schools with adequate infrastructures or the percentage of teachers lacking specific skills and needing training. This is the sampling approach pursued by TALIS. Accordingly, no single survey will provide the full range of evidence for an ideal monitoring framework, and the combination of evidence from different surveys and assessments can provide richer data for system monitoring and diagnosis. Annex 9.A provides a description of various international surveys and assessments that could prove useful for national monitoring and assessment.

Leverage insights from institution-level external quality evaluations

National frameworks for quality assurance in education may include a range of institution-level quality assurance procedures. Though specific evaluation and quality assurance procedures may vary in their characteristics, schools tend to undergo periodic evaluation by public inspection authorities (OECD, 2013[66]), while higher education institutions are subject to external accreditation (at institution and programme level) by public and private bodies (OECD, 2013[66]; OECD, 2019[67]).

School inspections and external evaluations of higher education institutions often give rise to a formal written report detailing the findings of the evaluator(s). In the vast majority of OECD countries, reports from formal school evaluations are made publicly available (OECD, 2015[68]). Similarly, reports of findings from external quality assurance audits of higher education institutions are made publicly available in many OECD jurisdictions.

Increasingly, inspection reports contain insights into the access and use of digital technologies:

- In **Slovakia**, for example, the State School Inspectorate's central evaluation framework includes the use of digital technologies for teaching as an explicit criterion for the evaluation of education facilities and resources in schools (European Commission/EACEA/Eurydice, 2015, p. 153[69]).
- Likewise, **Scotland**'s Digital Learning and Teaching Strategy stressed the importance of aligning self-evaluation guidance for schools and school inspection criteria with its vision for digital education. Specifically, Education Scotland committed to ensuring that self-evaluation guidance references the importance of using digital technology to enhance learning and teaching, that inspections include a focus on the effective and innovative use of digital technology, and that inspectors have a sound understanding of effective and innovative uses of digital technology in education (Scottish Government, 2016, p. 29[70]).
- In **New Zealand**, the effective use of digital devices and digital resources for learning is listed as one of the indicators for "Leadership and Excellence" assessed in school evaluations (Education Review Office New Zealand, 2016[71]).

A similar trend is observed in Vocational Education and Training, under the drive of several EU initiatives, with the development of guidelines for quality assurance in e-learning (Vaiouli, 2021[72]).

In higher education, few examples exist of fully developed national standards and guidelines for quality assurance of education delivered online. However, many countries are in the process of revising their existing guidelines, as a reaction to the COVID-19 pandemic, and taking into account the proliferation of online, hybrid and blended programmes. A recent OECD review shows that, as of 2022, 19 OECD countries now have specific guidelines or regulations in place covering online, hybrid or blended learning (Staring et al., 2022[73]). As a result, it is likely that future external evaluation reports will have more information and insight from evaluators on the use of digital technologies within education institutions.

The wealth of information available in individual evaluation reports provides a potentially valuable source of insight into the use, perception and impact of digital technologies within schools and higher education institutions. The qualitative nature of the reports and their lack of structured content has stymied attempts to efficiently gain insights, and in a comparable way. However, in jurisdictions where a common report structure is in place, new meta-analytical and content analysis techniques are opening up possibilities for structured extraction of insights and reflections about digital technologies. For example, a recent large-scale study of school inspection reports in the **United Kingdom** demonstrated the potential to use automated text mining to complement small-scale manual qualitative analysis (Bokhove and Sims, 2020[74]).

A European database of external quality assurance reports from higher education institutions (DEQAR) has been initiated, which contains more than 75 000 external programme and institutional accreditation reports for more than 3 200 European institutions (EQAR, n.d.[75]). Although the report structures are not comparable across jurisdictions, and the content is not standardised, researchers are beginning to use the database to conduct pilot analyses (for example (EQAR, n.d.[76])). Potentially the DEQAR may yield new insights into the state of digital higher education across Europe.

Support the generation of research evidence on the impact of digital education and promote greater use of research insights

Supporting the selection, suitability and effective pedagogical use of digital technologies requires a good understanding of their impact on student learning and non-cognitive outcomes. As described in the preceding chapters, rigorous evidence on the causal effects of digital education technologies remains sparse. However, policy makers can play an important role in strengthening this evidence base on the impact of digital education technologies. Government statistical agencies can support this effort by investing in data collections that generate descriptive information about the use of digital technologies and combine them with the collection and consolidation of administrative and performance data. Public research funding bodies can invest in research that yields reliable inferences about the causal effect of digital technologies. Decision makers can also promote policy experimentation and pilots and ensure their systematic evaluation (Köster, Shewbridge and Krämer, 2020[77]).

Even where research is available, the results of individual studies are generally specific to a particular context or student cohort type or focus on the presence or use of a single technology. This fragmented research landscape calls for more attention at national levels to assess, curate, and broker available evidence in order to integrate research results into the development of policy and practice. However, the state of knowledge mobilisation for decision making is education is often considered underdeveloped compared to some other fields, notably the health sector, although the number of intermediary organisations aimed at mobilising and communicating research evidence has increased over the last two decades (Torres and Steponavičius, 2022[78]). As a result, education research is often perceived to be less influential and less useful in the development of policy or in changing practice (Rycroft-Smith, 2022[79]).

Many countries have made efforts to improve the capacity to integrate evidence through the development of organisations with a specific mandate to review and curate research, and platforms that are intended to disseminate research in an accessible way. Examples of such initiatives include the Teaching and Learning Toolkit of the **United Kingdom**'s Educational Endowment Foundation's "What Works" centre (EEF, n.d.[80]), the Clearinghouse for Educational Research in **Denmark** (DPU, 2022[81]) and the **Swiss** Co-ordination Centre for Research in Education. In the **United States**, the Campbell Collaboration was conceived and established in 2000 as an education-focused version of the Cochrane Collaboration, which has been providing systematic reviews of heath care research since 1994. Regional Campbell centres have since been established, for the Nordic countries, United Kingdom and Ireland, and in South Asia (Campbell Collaboration, n.d.[82]).

Despite progress, not all efforts at knowledge brokerage in education have gained traction, and few of them specifically deal with the topic of digitalisation. This stands in contrast to the field of health, where national Health Technology Assessment organisations, whose mission is to review evidence and provide an assessment of the value of health technologies, are commonplace (INAHTA, n.d.[83]).

As part of the development of a national monitoring and evaluation framework, governments could thus explore ways of applying the health technology assessment approach to education technologies, through expansion of the remit of existing organisations, or the creation of new ones. For example, the **Swedish** Health Technology Association expanded its original remit to cover systematic reviews of social services (SBU, n.d.[84]). If resources do not permit the establishment of a permanent function, governments could consider jointly developing a function with regional partners or neighbouring countries. Governments can also consider funding systematic reviews or meta-analyses of research on a regular basis, to ensure that emerging evidence can be used to inform policy and practice. For instance, the Government of **Scotland** has invested in strengthening the evidence on digital education technologies by commissioning and disseminating a review of the scientific literature. The review aimed to identify the impacts that digital technology has on learning and teaching in primary and secondary schools and, more specifically, how digital technology can support and contribute to the government's five educational priorities: Raising attainment, tackling inequalities and promoting inclusion, improving transitions into employment, enhancing parental engagement, and improving the efficiency of the education system (ICF Consulting Services Ltd, 2015[85]). The review was commissioned after an Education Scotland report had concluded that change in the use of technologies in schools "has been modest at best" and that digital technologies could have a much more significant influence on learning which motivates learners and encourages career ambitions using technologies.

Design new approaches to evidence development, drawing on emerging methodologies and commercial data sources

Another direction for policy would be to capitalise on the process of digital transformation itself to strengthen the evidence base of effective digital education. Education data mining (i.e. the application of data analytics to answer education research questions) and learning analytics (i.e. the use of data analytics to understand and improve teaching and learning) have been recognised as an emerging field of research for more than a decade (Romero and Ventura, 2013[86]), and methodology continues to improve, along with access to research datasets. The use of digital tools, including educational software in the classroom thus generates a range of potentially valuable data, providing new insights into usage patterns, how they might link to user profiles and lead to different learning outcomes.

In fact, digitalisation involves new measurement opportunities: combined with student outcomes data, the rich data generated by LMS and virtual learning environments can generate rich insights into student engagement in learning and can be used to support student success. Next to national administrative data collections and surveys of higher education students and staff, learning analytics can now serve as an additional source of evidence. For instance, data generated from widely used digital learning platforms provide unprecedented opportunities to evaluate the effectiveness of pedagogical practices. However, this potential has not frequently been exploited, owing to the need to create new networks of collaboration linking data custodians, researchers, and EdTech firms. In some countries, public authorities have begun to leverage existing, widely used digital learning platforms for rigorous education research. In the **United**

States, for example, the Institute for Education Sciences has launched five projects linked to learning platforms, one of which, for example, is developing a plug-in to widely used LMS that enables teachers or researchers to collect informed consent, assign different versions of online learning activities to students, and export de-identified study data for analysis (Institute of Education Sciences, n.d.[87]).

Apart from complexity challenges associated with the coordination between multiple private and public stakeholders, sensitivities and caution regarding the implications for privacy and the fairness of decision processes have so far stood in the way of using learners' "digital footprints", at the level of individual classrooms, or at scale (Slade and Prinsloo, 2013[88]). Policy makers and education stakeholders are also increasingly aware of and responsive to the need for robust policies and regulations to protect learner privacy. For those elements of data mining and learning analytics where regulation does not yet generally exist (such as the use of algorithms), there is a growing push for an ethical approach. For example, recent OECD analysis stresses the need for humans to continue to play a key role in decision making processes with regard to engagement with at-risk students, rather than fully automating them (OECD, 2021[19]). International education organisations such as the International Council for Distance Education and the Association for the Advancement of Computing in Education have also collaborated on the development of global guidelines for ethical use of learning analytics (AACE, 2019[89]).

Other than learning analytics and education data mining, there is potential to derive insights about learner characteristics, motivations, pathways and outcomes from so-called "alternative data sources" such as citizen-generated, open-source or commercial data. Building capacity for making use of alternative data sources and developing the methodological skills needed to use them in robust evaluative processes requires resources beyond what many individual governments can allocate. Thus, in the digital era, a next-generation monitoring and evaluation infrastructure for policy making may need to increasingly rely on partnerships with the private sector and research organisations, as well as stakeholder engagement in order to tap the potential of emerging data sources (OECD, 2019[90]). Few examples can be found to date of the systematic integration of alternative data into the monitoring and evaluation of digital education. One example is the Centre for European Policy Studies (CEPS) Index of Readiness for Digital Lifelong Learning, which was developed as a collaboration between CEPS and Grow with Google, and used data from Google searches to assess learner interest in digital education (CEPS, 2020[59]).

Potential indicators to monitor and evaluate digital education ecosystems

Digitalisation in education is a multifaceted policy issue. Effective monitoring of the penetration and impact of digitalisation must take account of the extent to which infrastructure is in place to support digitalisation, the effective use of digitalisation in teaching and learning, and the extent to which digitalisation is having a positive impact on learners. The analysis and findings of the previous chapters, along with the considerations put forward in this Chapter, lead to a proposal of key generic indicators for digital education that countries should seek to monitor using existing national or international sources of data. These indicators are applicable to all levels of education and, together, should provide national governments with a comprehensive viewpoint of the extent to which their education system is integrating and making effective use of digital technologies.

Table 9.4 shows a proposal for generic indicators that should be prioritised in the development of a national monitoring and evaluation infrastructure. Ideally, data sources to populate these indicators should permit for regular assessment of the extent to which the indicator values are equal across the system, for example across different regions of the country, or across socio-economic groupings of national importance.

Table 9.4. Proposed generic indicators for priority inclusion in national monitoring and evaluation frameworks for digitalisation in education

	Analytical dimension	Indicator	Potential sources of national data	Examples of potential international indicators
1	Strategic Vision for Digital Education	Existence of a strategic vision and associated action plan (e.g. with measurable, time-bound objectives with respect to digitalisation in education)	Policy questionnaire	Recent publication of a new or updated policy strategy for digital education (OECD Policy Questionnaire on governance and public-private relations regarding education data and digital technology) For which elements of digitalisation do public bodies set higher education system or subsystem level targets or objectives (OECD Higher Education Policy Survey)
2	Adapting pedagogical approaches, curricula and assessments	Take-up and attitudes on the usage and impact of digital education technology	Student, educator and education institution management surveys, school inspection or quality assurance reports	Percentage of students who report the use of a digital device for learning or teaching during lessons in the past month, by subject (e.g. test language lessons, science, mathematics) and by type of user (teacher only, student only, student and teacher only) (PISA)
				Frequency with which students engage in a range of ICT-based learning activities during lessons (searching the internet to collect information; downloading/uploading/browsing material from school's website; sending or reading email messages; chatting online for school work; using a word processing spreadsheet or presentation programme; code/programming apps, programmes or robots; use of computers when working in groups; participating in online training programmes; learning with educational software, games, apps and quizzes) (ESSIE)
				Frequency with which students use a range of ICT learning materials in lessons (exercise software, online quizzes and tests; learning applications on a smartphone or tablet; text edition tools; image edition tools; multimedia production tools; broadcasting tools; data logging tools; computer simulations; digital learning games, computer/video games) (ESSIE)
				Percentage of students in schools where teachers and head-teachers hold positive opinions about whether ICT should be used for students (ESSIE)
				Percentage of students whose parents hold positive attitudes towards the use of ICT at school (ESSIE)
				Percentage of students who hold positive attitudes towards the use of ICT at school (ESSIE)
				Potential indicators for higher education systems could be developed by adding a specific question on attitudes to digitalisation in international surveys of students and staff (e.g. Eurostudent for students or the OECD International Survey of Science for staff)
		Adaptation of the curriculum to digital education	Policy questionnaire	Existence of rules or guidelines about specific uses of digital technology in class (e.g. as part of curriculum requirements) (OECD Policy Questionnaire on governance and public-private relations regarding education data and digital technology)
3	Governance, guidance and regulation for digital education	Existence of participatory mechanisms for stakeholder engagement and co-ordination with the private sector	Policy questionnaire	Existence of formal processes for government engagement with EdTech companies (OECD Policy Questionnaire on governance and public-private relations regarding education data and digital technology)
		Existence of regulation or guidelines about digital security, the protection of personal data and the use of algorithmic models	Policy questionnaire	Existence of specific rules and guidelines about digital security and the protection of personal data (Y/N) (OECD Policy Questionnaire on governance and public-private relations regarding education data and digital technology) Existence of rules or guidelines about the use of algorithmic models in education (e.g. allowing some types of algorithms and forbidding others) (OECD Policy Questionnaire on governance

	Analytical dimension	Indicator	Potential sources of national data	Examples of potential international indicators
				and public-private relations regarding education data and digital technology) Existence of related policy levers regarding the ethical use of data and algorithms in the delivery of higher education (OECD Higher Education Policy Survey)
		Coverage of digital education in quality assurance procedures	Policy questionnaire	Integration of criteria relating to digital education in school inspection / evaluation frameworks (Eurydice)
				External quality assurance guidelines or methodology for higher education institutions or programmes have been revised to incorporate digital provision (OECD Higher Education Policy Survey)
4	Funding and procurement for digital education	Support for institutional procurement strategies and budget practices	Policy questionnaire	Direct procurement of digital technologies, price negotiation with suppliers at government-level or provision of guidance to education institutions for the procurement of digital education technologies (OECD Policy Questionnaire on governance and public-private relations regarding education data and digital technology) Aspects of digitalisation that have specific public allocations been made to higher education institutions in the past five years (e.g. from targeted, special-purpose or capital funds, or provided directly by a central body (OECD Higher Education Policy Survey)
5	Accessible, innovative and high-quality infrastructure for digital education	Fast and reliable Internet connection in education institutions (average access and gaps)	NRENs, education institution reports	Percentage of students in schools where principals' report that the schools' Internet bandwidth is sufficient (PISA)
				Socio-economic, urban/rural divides in the percentage of students who report having access to an Internet connection at school (PISA)
				Percentage of students who are in schools with high-speed Internet (above 100 mbps) (ESSIE)
				For higher education, international indicators could potentially be constructed from the comparative data collected annually in the Géant and published in the NREN Compendium
		Fast and reliable Internet connection at home (average access and gaps)	National statistics	Percentage of households with either 1) fast broadband (NGA), 2) Fixed Very High Capacity Network (VHCN), or 3) Fiber to the Premises (FTTP) (DESI – Digital Economy and Society Index)
		Student access to key technological equipment in education institutions (e.g. level and gaps)	Education institution reports or surveys	Percentage of principals reporting that shortages or inadequacy of digital technology for instruction (e.g. software, computers, tablets, smart boards) hinder school's capacity to provide quality instruction (TALIS)
				Urban/rural or socio-economic gap in students' access to a portable computer in schools (PISA)
		Student access to key technological equipment at home (e.g. level and gaps)	Surveys	Socio-economic gap in students' access to a computer they can use for school work at home (PISA)
				For higher education, potential indicators could be developed by adding a specific question on access to equipment in international surveys of students (e.g. Eurostudent)
				Percentage of students with access to ICT devices at home (desktop computers without internet access; desktop computers with internet access; laptops, tablets, netbooks or mini notebooks without internet access; laptops, tablets, netbooks or mini notebooks with internet access; digital readers; video gaming systems; handheld game console; mobile phone without internet access; mobile phone with internet access; portable music or video player; camcorder or digital camera; wearable devices) (ESSIE)

	Analytical dimension	Indicator	Potential sources of national data	Examples of potential international indicators
		Innovation incentives or support for digital education technologies	Surveys	Government subsidies of research and development to encourage EdTech innovation (e.g. specific subsidies or commissions for R&D in education technology) (OECD Policy Questionnaire on governance and public-private relations regarding education data and digital technology) Provision of monetary incentives by government authorities for the development of educational software or learning resources (OECD Policy Questionnaire on governance and public-private relations regarding education data and digital technology) Incentivising or supporting policies are available in your jurisdiction to enhance digital capabilities in higher education institutions (e.g. innovation funds, peer networks, awards and recognition for innovation) (OECD Higher Education Policy Survey)
6	Capacity building for digital education	Teacher's digital skills	Self-reports in national surveys, national skills assessment	Teachers' self-efficacy with supporting student learning through the use of digital technologies (TALIS)
				Teachers' confidence in their digital competence in 5 competency areas (information and data literacy; communication and collaboration; digital content creation; safety; problem solving) (expressed in percentage of students) (ESSIE)
				Resources provided by public authorities or publicly supported non-governmental organisations (e.g. co-operatives, foundations, associations) to cultivate digital capabilities in staff teaching in higher education institutions (e.g. training on digital pedagogy, training on relevant software) (OECD Higher Education Policy Survey)
		Teacher Professional Development Needs	Surveys	Percentage of teachers expressing a high need for further training on ICT skills for teaching (Need for further training) (TALIS (2018))
		Parents' capacity to support their children's digital learning	Self-reports in national surveys, national skills assessment	Percentage of students with parents confident in teaching their children about safe and responsible Internet behaviour (scale of 4 confidence levels developed based on parents' confidence in teaching their child how 1) to behave safely on line, e.g. prevent cyberbullying, 2) to behave safely to protect his/her privacy and 3) to manage their digital identity and reputation) (ESSIE)
		Students' digital skills	Self-reports in national surveys, national skills assessment	Students' perceived ICT competence (PISA)
				Student computer and information literacy (CIL) or computational thinking (CT) achievement at 4 levels of proficiency (ICILS) Association of CIL/CT achievement with 1) gender, 2) SES background, 3) immigrant background, and 4) language background (ICILS)
7	Human resource policies for digital education	Incentives and support for teachers'	Surveys, policy questionnaire	Percentage of students in schools whose principal agreed or strongly agreed that teachers have sufficient time to prepare lessons integrating digital devices (PISA)

	Analytical dimension	Indicator	Potential sources of national data	Examples of potential international indicators
		engagement in digital education		How delivery of education through digital means is taken into account in workload allocation models for teaching staff (OECD Higher Education Policy Survey)
				Percentage of students in schools where principals report the school has sufficient qualified technical staff (PISA)
				Percentage of students in schools with incentives to reward teachers for using ICT in teaching and learning (additional training hours; reduced teaching hours; additional ICT equipment for the classroom; financial incentives; competitions and prizes; and honorary titles) (ESSIE)
8	Monitoring and evaluation for digital education	Coverage of digital education in monitoring and evaluation processes	Policy questionnaire	Existence of rules or guidelines about the monitoring or evaluation of the effectiveness of using digital technologies in education (e.g. providing public information about evaluation results) (OECD Policy Questionnaire on governance and public-private relations regarding education data and digital technology)
		Coverage of digital education in monitoring and evaluation processes		Percentage of schools with a policy or actions to assess the outcomes of using ICT for teaching and learning (ESSIE)

The indicators described in Table 9.4 may be monitored using national and international data sources such as ICILS (IEA, 2022[91]), PISA (OECD, 2022[92]), TALIS (OECD, 2022[93])or GÉANT (GÉANT Association, 2022[94]). In addition, many relevant international indicators exist that provide insight on the presence of enabling factors for digitalisation in education, and that can replace or supplement national data sources.

Key messages

In light of the ambiguous research evidence on the effects of digital technologies on learning outcomes and the high costs associated with digitalising education systems, careful monitoring and evaluation of digital education policies is paramount. However, this chapter highlights significant gaps in national evidence structures regarding the implementation and effectiveness of digital education policies: Lacking information on both the investments in digital education and policy outcomes undermine governments' capacity to assess the cost effectiveness of digital education policies. Similarly, a lacking understanding of the extent to which digital education policies have been implemented and where gaps persist limit governments' ability to direct policy-focus to where it is most needed. To build a stronger evidence foundation for digital education policies, this chapter thus emphasises the importance of comprehensive monitoring and evaluation frameworks.

In designing monitoring and evaluation structures, governments must strike a balance between gathering relevant evidence and minimising the reporting burden for institutions and education stakeholders. Towards this end, this chapter suggests a range of existing data sources that national governments might leverage to monitor and benchmark the state of digitalisation in their education systems. These include – among others – data from international surveys or comparative policy indicators. The analysis also highlights some promising examples of countries which have adapted their evidence structures to digital education, for instance through including a digital lens to national administrative or statistical surveys or including measures of digital education in external evaluation reports of education institutions. Finally, the chapter suggests a list of possible indicators which could be used to track the progress of education systems along the analytical dimensions of this report and international data collections that countries might leverage for this purpose.

References

AACE (2019), *Global Guidelines: Ethics in Learning Analytics*, https://www.learntechlib.org/p/208251/. [89]

Balaban, I., N. Begicevic Redjep and M. Klacmer Calopa (2018), "The Analysis of Digital Maturity of Schools in Croatia", *International Journal of Emerging Technologies in Learning (iJET)*, Vol. 13/06, p. 4, https://doi.org/10.3991/IJET.V13I06.7844). [36]

Bertelsmann Siftung (n.d.), *Monitor Digitale Bildung*, https://www.bertelsmann-stiftung.de/de/unsere-projekte/teilhabe-in-einer-digitalisierten-welt/projektthemen/projektthemen-monitor/ (accessed on 9 August 2022). [54]

Bokhove, C. and S. Sims (2020), "Demonstrating the potential of text mining for analyzing school inspection reports: a sentiment analysis of 17,000 Ofsted documents", *https://doi.org/10.1080/1743727X.2020.1819228*, Vol. 44/4, pp. 433-445, https://doi.org/10.1080/1743727X.2020.1819228. [74]

Bonne, L. and J. MacDonald (2019), *Secondary schools in 2018: Findings from the NZCER national survey*, https://www.researchgate.net/publication/342875891_Secondary_schools_in_2018_Findings_from_the_NZCER_national_survey (accessed on 21 August 2022). [55]

Bowen, W. (2012), "The 'Cost Disease' in Higher Education: Is Technology the Answer?". [18]

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. [16]

Campbell Collaboration (n.d.), *Better evidence for a better world -*, https://www.campbellcollaboration.org/better-evidence.html# (accessed on 12 August 2022). [82]

Cellini, S. (2021), *How does virtual learning impact students in higher education?*, https://www.brookings.edu/blog/brown-center-chalkboard/2021/08/13/how-does-virtual-learning-impact-students-in-higher-education/. [17]

Centre for Applied Psychology at the Faculty of Philosophy in Rijeka (2018), *Scientific Research on the Effects of the Project "e-Schools: Establishing a System for the Development of Digitally Mature Schools (Pilot Project)" Conclusions and recommendations*, https://pilot.e-skole.hr/wp-content/uploads/2019/11/Conclusions_and_recommendations.pdf (accessed on 27 September 2022). [37]

CEPS (2020), *Index of Readiness for Digital Lifelong Learning – CEPS*, https://www.ceps.eu/ceps-publications/index-of-readiness-for-digital-lifelong-learning/ (accessed on 12 August 2022). [59]

Department of Education, Australia NSW (n.d.), *Schools Digital Strategy - How the SDS will help you*, https://education.nsw.gov.au/content/dam/main-education/en/home/about-us/strategies-and-reports/schools-digital-strategy/strategy-resources/documents/03_Schools_Digital_Strategy_How_the_SDS_will_help_you.pdf (accessed on 20 August 2022). [34]

Digital Agency et al. (2022), *Roadmap on the Utilization of Data in Education*, https://www.digital.go.jp/assets/contents/node/basic_page/field_ref_resources/0f321c23-517f-439e-9076-5804f0a24b59/20220307_en_education_outline_01.pdf. [42]

Direcao-general de estatisticas de educacao de ciencia (2020), *Indicators*, https://observatorio.incode2030.gov.pt/indicadores/ (accessed on 19 May 2023). [46]

DPU (2022), "Dansk Clearinghouse for Uddannelsesforskning". [81]

Education Review Office New Zealand (2016), "School evaluation indicators : effective practice for improvement and learner success.", https://ero.govt.nz/how-ero-reviews/schoolskura-english-medium/school-evaluation-indicators (accessed on 16 December 2022). [71]

EEF (n.d.), *Teaching and Learning Toolkit*, https://educationendowmentfoundation.org.uk/education-evidence/teaching-learning-toolkit (accessed on 12 August 2022). [80]

EQAR (n.d.), *Database of External Quality Assurance Results*, https://www.eqar.eu/qa-results/search/ (accessed on 1 August 2022). [75]

EQAR (n.d.), *Pilot studies - EQAR*, https://www.eqar.eu/about/projects/deqar-project/pilot-studies/#research-questions-2 (accessed on 12 August 2022). [76]

Estevez, E. et al. (2021), *Portugal Leapfrogging Digital Transformation*, CAF. [44]

European Commission (2022), *Broadband Coverage in Europe in 2021 | Shaping Europe's digital future*, https://digital-strategy.ec.europa.eu/en/library/broadband-coverage-europe-2021 (accessed on 21 August 2022). [58]

European Commission (2019), *2nd Survey of Schools : ICT in Education*, EC Directorate-General for Communications Networks, Content and Technology, https://doi.org/10.2759/23401. [8]

European Commission (2013), *Survey of Schools: ICT in Education - Benchmarking Access, Use and Attitudes to Technology in Europe's Schools*, Directorate-General for the Information Society and Media (European Commission), Brussels, https://doi.org/10.2759/94499. [9]

European Commission/EACEA/Eurydice (2019), *Digital Education at School in Europe*, Eurydice Report. Luxembourg: Publications Office of the European Union, https://eacea.ec.europa.eu/national-policies/eurydice/content/digital-education-school-europe_en (accessed on 4 August 2020). [6]

European Commission/EACEA/Eurydice (2015), *Assuring Quality in Education: Policies and Approaches to School Evaluation in Europe*, Publications Office of the European Union, Luxembourg, https://doi.org/10.2797/65355. [69]

Eurydice (2022), *National Education Systems*, https://eurydice.eacea.ec.europa.eu/national-education-systems (accessed on 8 June 2021). [62]

Fraillon, J. et al. (2019), "PREPARING FOR LIFE IN A DIGITAL WORLD IEA International Computer and Information Literacy Study 2018 International Report". [10]

GÉANT Association (2022), *GÉANT COMPENDIUM*, https://compendiumdatabase.geant.org/ (accessed on 30 September 2022). [94]

HESA (2020), *Student 2020/21 - Location of study*, https://www.hesa.ac.uk/collection/c20051/a/locsdy (accessed on 10 August 2022). [50]

Heymans, P. et al. (2018), *Monitor for ICT integration in flemish education (MICTIVO): The theoretical and methodological framework*. [7]

Hu'o'ng, H. (2022), "Chuyển đổi số giáo dục: Giáo viên và học sinh phải ở vị trí trung tâm - Tuổi Trẻ Online", https://tuoitre.vn/chuyen-doi-so-giao-duc-giao-vien-va-hoc-sinh-phai-o-vi-tri-trung-tam-20221028111922459.htm (accessed on 24 January 2023). [61]

ICF Consulting Services Ltd (2015), *Literature Review on the Impact of Digital Technology on Learning and Teaching*, Scottish Government, Edinburgh, http://www.gov.scot/publications/literature-review-impact-digital-technology-learning-teaching/ (accessed on 16 December 2022). [85]

IEA (2022), *ICILS*, https://www.iea.nl/studies/iea/icils (accessed on 30 September 2022). [91]

INAHTA (n.d.), *The International Network of Agencies for Health Technology Assessment*, https://www.inahta.org/ (accessed on 11 August 2022). [83]

Institute of Education Sciences (n.d.), *Digital Learning Platforms to Enable Efficient Education Research Network*, https://ies.ed.gov/ncer/projects/program.asp?ProgID=2119 (accessed on 23 February 2023). [87]

Ireland, G. (2022), *Digital Strategy for Schools to 2027*, https://www.gov.ie/en/publication/69fb88-digital-strategy-for-schools/#digital-strategy-for-schools-to-2027 (accessed on 19 August 2022). [38]

Jones, C. et al. (2022), "Building on Aotearoa New Zealand's Integrated Data Infrastructure", *Harvard Data Science Review*, Vol. 4/2, https://doi.org/10.1162/99608F92.D203AE45. [52]

Köster, F., C. Shewbridge and C. Krämer (2020), *Promoting Education Decision Makers' Use of Evidence in Austria*, Educational Research and Innovation, OECD Publishing, Paris, https://doi.org/10.1787/0ac0181e-en. [77]

Lorenceau, L., C. Maric and T. Mostafa (2019), *Upgrading the ICT questionnaire items in PISA 2021 | OECD Education Working Papers*, https://www.oecd-ilibrary.org/education/upgrading-the-ict-questionnaire-items-in-pisa-2021_d0f94dc7-en (accessed on 9 August 2022). [20]

Miller, E. and J. Shedd (2019), "The History and Evolution of IPEDS", *New Directions for Institutional Research*, Vol. 2019/181, pp. 47-58, https://doi.org/10.1002/IR.20297. [51]

Ministry of Education (2014), *Extramural students' participation and achievement: Trends, patterns and highlights*, https://thehub.swa.govt.nz/assets/documents/41821_Extramural-Students-Report-07022014_0.pdf. [53]

Ministry of Education Italy (2022), *PIANO SCUOLA 4.0*, https://pnrr.istruzione.it/wp-content/uploads/2022/07/PIANO_SCUOLA_4.0_VERSIONE_GRAFICA.pdf (accessed on 27 September 2022). [35]

Mullis, I. et al. (2020), *TIMMS 2019 International Results in Mathematics and Science*, https://www.iea.nl/sites/default/files/2020-12/TIMSS%202019-International-Results-in-Mathematics-and-Science.pdf (accessed on 22 February 2023). [95]

National Center for Education Statistics (n.d.), *https://nces.ed.gov/ipeds/use-the-data/distance-education-in-ipeds*. [49]

National Forum for the Enhancement of Teaching and Learning (2016), *Ireland's Higher Education Technical Infrastructure: A Review of Current Context, with Implications for Teaching and Learning Enhancement – National Resource Hub*, https://hub.teachingandlearning.ie/resource/irelands-higher-education-technical-infrastructure-a-review-of-current-context-with-implications-for-teaching-and-learning-enhancement/ (accessed on 8 August 2022). [15]

NCES (2021), *Distance Education in IPEDS*, https://nces.ed.gov/ipeds/use-the-data/distance-education-in-ipeds (accessed on 3 January 2023). [48]

NWO (2023), *National Growth Fund | NWO*, https://www.nwo.nl/en/researchprogrammes/national-growth-fund (accessed on 3 April 2023). [96]

OECD (2023), *Advancing Digital Maturity in Croatia's Higher Education System*, OECD Publishing, Paris, https://doi.org/10.1787/26169177. [39]

OECD (2022), *Internet access* (indicator), https://doi.org/10.1787/69c2b997-en (accessed on 1 August 2022). [4]

OECD (2022), *Mending the Education Divide: Getting Strong Teachers to the Schools That Need Them Most*, TALIS, OECD Publishing, Paris, https://doi.org/10.1787/92b75874-en. [11]

OECD (2022), *PISA*, https://www.oecd.org/pisa/ (accessed on 30 September 2022). [92]

OECD (2022), *TALIS - The OECD Teaching and Learning International Survey - OECD*, https://www.oecd.org/education/talis/ (accessed on 30 September 2022). [93]

OECD (2022), *The OECD Going Digital Measurement Roadmap | OECD Digital Economy Papers*, https://www.oecd-ilibrary.org/science-and-technology/the-oecd-going-digital-measurement-roadmap_bd10100f-en (accessed on 1 August 2022). [3]

OECD (2022), "What makes students' access to digital learning more equitable?", *Teaching in Focus*, No. 43, OECD Publishing, Paris, https://doi.org/10.1787/e8107345-en. [28]

OECD (2021), *Design and implementation of a comprehensive monitoring system in Austria*, https://www.oecd.org/fr/education/design-and-implementation-of-a-comprehensive-monitoring-system-in-austria-956e3d9d-en.htm (accessed on 10 August 2022). [40]

OECD (2021), *How to measure innovation in education?*, https://www.oecd.org/education/ceri/How-to-measure-innovation-in-education.pdf (accessed on 12 August 2022). [21]

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. [19]

OECD (2021), "Supporting teachers' use of ICT in upper secondary classrooms during and after the COVID-19 pandemic", *Teaching in Focus*, No. 41, OECD Publishing, Paris, https://doi.org/10.1787/5e5494ac-en. [27]

OECD (2021), *Supporting the Digital Transformation of Higher Education in Hungary*, Higher Education, OECD Publishing, Paris, https://doi.org/10.1787/d30ab43f-en. [2]

OECD (2021), *The State of School Education: One Year into the COVID Pandemic*, OECD Publishing, Paris, https://www.oecd-ilibrary.org/docserver/201dde84-en.pdf?expires=1632997342&id=id&accname=guest&checksum=AB7A563077A4309BB5207DC1BF8D8508 (accessed on 30 September 2021). [23]

OECD (2020), *A roadmap toward a common framework for measuring the digital economy: Report for the G20 Digital Economy Task Force*, OECD Publishing, Paris, https://www.oecd.org/digital/ieconomy/roadmap-toward-a-common-framework-for-measuring-the-digital-economy.pdf (accessed on 22 January 2021). [33]

OECD (2020), *Building Capacity for Evidence-Informed Policy-Making: Lessons from Country Experiences*, OECD Public Governance Reviews, OECD Publishing, Paris, https://doi.org/10.1787/86331250-en. [41]

OECD (2020), *Digital Government Index: 2019 results*, https://www.oecd.org/gov/digital-government-index-4de9f5bb-en.htm (accessed on 29 March 2022). [65]

OECD (2020), *Strengthening the Governance of Skills Systems: Lessons from Six OECD Countries*, OECD Skills Studies, OECD Publishing, Paris, https://doi.org/10.1787/3a4bb6ea-en. [43]

OECD (2020), *TALIS 2018 Results (Volume II): Teachers and School Leaders as Valued Professionals*, TALIS, OECD Publishing, Paris, https://doi.org/10.1787/19cf08df-en. [13]

OECD (2020), "Teachers' training and use of information and communications technology in the face of the COVID-19 crisis", *Teaching in Focus*, No. 35, OECD Publishing, Paris, https://doi.org/10.1787/696e0661-en. [26]

OECD (2019), *Benchmarking Higher Education System Performance*, Higher Education, OECD Publishing, Paris, https://doi.org/10.1787/be5514d7-en. [67]

OECD (2019), "Building a monitoring and evaluation framework for open government", in *Open Government in Biscay*, OECD Publishing, Paris, https://doi.org/10.1787/a70e8be3-en. [1]

OECD (2019), *Measuring the Digital Transformation: A Roadmap for the Future*, OECD Publishing, Paris, https://doi.org/10.1787/9789264311992-en. [90]

OECD (2019), *OECD Skills Outlook 2019: Thriving in a Digital World*, OECD Publishing, Paris, https://doi.org/10.1787/df80bc12-en. [22]

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. [12]

OECD (2018), *Education Policy Outlook 2018: Putting Student Learning at the Centre*, OECD Publishing, Paris, https://doi.org/10.1787/9789264301528-en. [63]

OECD (2015), *Education at a Glance 2015: OECD Indicators*, OECD Publishing, Paris, https://doi.org/10.1787/eag-2015-en. [68]

OECD (2015), "Teaching with technology", *Teaching in Focus*, No. 12, OECD Publishing, Paris, https://doi.org/10.1787/5jrxnhpp6p8v-en. [25]

OECD (2013), *Synergies for Better Learning - an international perspective on evaluation and assessment*, https://doi.org/10.1787/9789264190658-en (accessed on 26 September 2022). [32]

OECD (2013), *Synergies for Better Learning: An International Perspective on Evaluation and Assessment*, OECD Reviews of Evaluation and Assessment in Education, OECD Publishing, Paris, https://doi.org/10.1787/9789264190658-en. [66]

OECD (2009), *Creating Effective Teaching and Learning Environments: First Results from TALIS*, TALIS, OECD Publishing, Paris, https://doi.org/10.1787/9789264068780-en. [24]

OECD et al. (2020), *SME Policy Index: Eastern Partner Countries 2020: Assessing the Implementation of the Small Business Act for Europe*, SME Policy Index, OECD Publishing, Paris/European Union, Brussels, https://doi.org/10.1787/8b45614b-en. [64]

Portugal, G. (2020), *Portugal Digital: Moving forward. Moving with a Purpose - Portugal's Action Plan for Digital Transition Contents*. [45]

Portulans Institute (2021), *The Network Readiness Index 2021*, https://networkreadinessindex.org/country/croatia/. [57]

Rathenau Instituut (2022), "Naar hoogwaardig digitaal onderwijs". [97]

Redecker, C. et al. (2017), "Digital Education Policies in Europe and Beyone: Key Design Principles for More Effective Policies", https://doi.org/10.2760/462941. [30]

República Portuguesa (n.d.), *Capacitação Digital das Escolas*, https://digital.dge.mec.pt/ (accessed on 26 September 2022). [47]

Romero, C. and S. Ventura (2013), "Data mining in education", *Wiley Interdisciplinary Reviews: Data Mining and Knowledge Discovery*, Vol. 3/1, pp. 12-27, https://doi.org/10.1002/WIDM.1075. [86]

Rycroft-Smith, L. (2022), "Knowledge brokering to bridge the research-practice gap in education: Where are we now?", *Review of Education*, Vol. 10/1, p. e3341, https://doi.org/10.1002/REV3.3341. [79]

SBU (n.d.), *About SBU*, https://www.sbu.se/en/about-sbu/ (accessed on 12 August 2022). [84]

Scottish Government (2016), *Enhancing Learning and Teaching Through the Use of Digital Technology: A Digital Learning and Teaching Strategy for Scotland*, https://www.gov.scot/publications/enhancing-learning-teaching-through-use-digital-technology/documents/ (accessed on 12 August 2022). [70]

Slade, S. and P. Prinsloo (2013), "Learning Analytics: Ethical Issues and Dilemmas", *American Behavioral Scientist*, https://doi.org/10.1177/0002764213479366. [88]

Staring, F. et al. (2022), *Digital higher education: Emerging quality standards, practices and supports*, https://www.oecd.org/education/digital-higher-education-f622f257-en.htm. [73]

The Campus Computing Project (2019), *The 2019 Campus Computing Survey*, https://www.campuscomputing.net/content/2019/10/15/the-2019-campus-computing-survey (accessed on 8 August 2022). [14]

Torres, J. and M. Steponavičius (2022), "More than just a go-between: The role of intermediaries in knowledge mobilisation OECD Education Working Paper No. 285", OECD, Paris, http://www.oecd.org/termsandconditions. (accessed on 1 June 2023). [78]

Trucano, M. (2019), *The case for a new Global Edtech Readiness Index*, https://blogs.worldbank.org/edutech/new-global-edtech-readiness-index (accessed on 12 August 2022). [56]

UEN and Connected Nation (2022), *2021 Utah School Technology Inventory Report*, Utah Education and Telehealth Network, Salt Lake City, https://www.uen.org/digital-learning/downloads/2021/21_UETN_Technology_Report.pdf (accessed on 12 August 2022). [5]

UNESCO (2022), "Guidelines for ICT in education policies and masterplans", https://unesdoc.unesco.org/ark:/48223/pf0000380926 (accessed on 26 September 2022). [31]

University of Kent, SWGfL and Bitdefender (2022), "Cyber Security in UK schools How well protected are schools and colleges in England and Wales?", https://swgfl.org.uk/assets/documents/cyber-security-report.pdf (accessed on 15 December 2022). [29]

Vaiouli, E. (2021), *ASSURING QUALITY OF E-LEARNING IN VET - HUB VET4EU2*, https://hub.vet4eu2.eu/blog/2021/04/27/assuring-quality-of-e-learning-in-vet/ (accessed on 22 August 2022). [72]

Venegas Marin, S. et al. (2021), *Where is EdTech working? Leveraging data for better EdTech policies*, https://blogs.worldbank.org/education/where-edtech-working-leveraging-data-better-edtech-policies (accessed on 21 August 2022). [60]

Annex 9.A. International surveys/assessments with information on digital education issues

The most relevant international surveys/assessments touching on digital education issues include:

- **The European Survey of *S*chools: ICT in Education (known as ESSIE)**

  This survey was commissioned by the EC with the aim to benchmark progress in ICT in schools, i.e. to provide detailed and up-to-date information related to access, use and attitudes towards the use of technology in education (European Commission, 2019[8]; European Commission, 2013[9]).

  ESSIE was first administered in 2011-12 and the second round was administered in 2017-18, and covered all EU member states as well as Iceland, Norway, Türkiye. The survey was carried out by a Consortium of Deloitte and IPSOS Mori.

  ESSIE focuses on the primary, lower secondary and upper secondary levels of education, and consists of an online survey, and interviews with head teachers, class teachers (one teacher at ISCED level 1 [International Standard Classification of Education], three teachers at ISCED levels 2 and 3), students (all students from one randomly selected class per level in each school, except ISCED level 1), and parents.

- **The International Computer and Information Literacy Study (ICILS)**

  This large-scale assessment was initiated by the IEA with the aim to assess core aspects of students' digital literacy, with a focus on computer literacy, information literacy and computational thinking. The study also aims to ascertain student preparedness for study, work, and a digital world, and addresses some aspects of digital citizenship (Fraillon et al., 2019[10]).

  ICILS is administered every five years since 2013. The second round was administered in 2018, and the third one will take place in 2023.

  The 2018 round of ICILS covered 13 countries and economies (among which 7 EU countries), while the next round will cover 33 countries and economies (among which 21 EU countries). Its target population are students at Grade 8 (average age: 13.5) and consists of an online survey administered to teachers and principals, alongside a national context questionnaire.

  The distinct advantage of ICILS as a monitoring tool for the enabling factors for digital education and skills is that it directly evaluates learners' digital skills, as a critical outcome measure to gauge the progress and success of digital strategies and action plans.

- **The OECD Teaching and Learning International Survey (TALIS)**

  This survey was commissioned by the OECD with the aim to provide robust international indicators and policy-relevant analysis on teachers and their principals and the schools they work in a timely and cost-effective manner (OECD, 2022[11]) (OECD, 2019[12]) (OECD, 2020[13]).

  TALIS was first administered in 2008. The following rounds were administered in 2013 and 2018, and the fourth round will take place in 2024. It will for the first time include (optionally) a direct assessment of teachers' pedagogical knowledge, with an emphasis on the use of digital resources and tools for teaching – hence will provide a first attempt at monitoring teachers' capacity for digital education.

  The survey development and implementation is carried out by a Consortium led by IEA.

TALIS covers 55 countries. It focuses on early childhood and care centres as well as the primary, lower secondary and upper secondary levels of education. It consists of an online survey of teachers and school principals.

- **The Progress in International Reading Literacy Study (PIRLS)**

  This large-scale assessment was initiated by the IEA with the aim to monitor system-level trends in student achievement in reading at Grade 4 in a global context, and to evaluate how well students read, interpret, and critique online information in an environment that looks and feels like the internet (ePIRLS). It also examines information technology in the classroom to better understand the classroom context.

  PIRLS is administered every five years since 2001. The following rounds were administered in 2006, 2011, 2016, and the fifth round took place in 2021. Its results will be launched in May 2023.

  The 2021 PIRLS round covers 27 countries and 5 benchmarking entities (including 21 EU countries). Its target population are students at Grade 4, and consists of an online survey administered to principals, teachers, students and parents alongside a national curriculum questionnaire.

- **The Trends in International Mathematics and Science Study (TIMSS)**

  This large-scale assessment was initiated by the IEA with the aim to monitor system-level trends in student achievement in mathematics and science at Grades 4 and 8 in a global context (Mullis et al., 2020[95]).

  TIMSS is administered every four years since 1995. The following rounds were administered in 1999, 2003, 2007, 2011, 2015, 2019, and the eighth round will take place in 2023.

  TIMSS covers 64 countries and 8 benchmarking entities. Its target population are students at Grade 4 and/or Grade 8 and it consists of an online (or paper-based) survey administered to principals, teachers, students and parents alongside a national curriculum questionnaire.

  There is limited information on digital technologies in education in TIMSS, except for indicators on access to computers during mathematics and sciences lessons, teachers' use of computers during mathematics and sciences lessons, and students' use of computers to take mathematics and sciences tests

- **The Programme for International Student Assessment (PISA)**

  This large-scale assessment was commissioned by the OECD with the aim to assess the extent to which 15-year-old students have acquired the key knowledge and skills essential for full participation in society.

  PISA was first administered in 2000. The following rounds were administered in 2003, 2006, 2009, 2012, 2015, 2018 and most recently in 2022. The results of the latest round will be published in December 2023. PISA covers 84 participating countries and economies.

More details on the technical parameters of these surveys/assessments are available from the International Large Scale Assessment gateway (https://www.ilsa-gateway.org/).

Annex 9.B. National monitoring and evaluation of high-level education digitalisation strategies by country

Annex Table 9.B.1. Monitoring and evaluation provisions of high-level education digitalisation strategies by country

Country/economy[1]	Monitoring and Evaluation Provisions for digital Education
Austria[C]	The initiatives under the Austrian 8-Point Plan Digital School are monitored in the course of professional project management and project control in the education ministry. Various key figures are also used, such as the number of digital devices issued to pupils. Monitoring is carried out on an ongoing basis. In addition, the use of digital devices will be evaluated in the 2022/23 school year. The focus of the evaluation will be on identifying scenarios for how schools use the devices in the classroom (in the various subjects etc.). The evaluation will not be a complete survey but will be implemented with a valid sample.
Belgium FL	The Flemish Community of Belgium has developed the Monitor for ICT integration in Flemish Education (MICTIVO) – a survey administered to pupils, teachers and school managers that is reoccurring every five years. The Survey covers a sample of around 20% of Flemish schools and evaluates the infrastructure and policy, perceptions, competencies and integration of ICT in primary and secondary education as well as in adult basic education (Heymans et al., 2018[7]).
Belgium FR[C]	While no detailed concept for monitoring and evaluation has been released yet, the education digitalisation strategy of the French Community of Belgium foresees the implementation of a monitoring tool to track the roll-out of the digital transition in schools with a particular focus on IT infrastructure.
Belgium GE[C]	No provisions on Monitoring and Evaluation.
Bulgaria[C]	Bulgaria currently features a range of broader strategies which touch on digital education such as the National Programme Digital Bulgaria 2025 or the Digital Transformation of Bulgaria for the period 2020-2030. These strategies foresee the regular release of interim reports updating on the progress of their implementation.
Croatia[C]	Monitoring and Evaluation is conducted as part of the Croatian E-Schools project which is currently rolled out in primary and secondary schools. Monitoring and evaluation are based on Croatia's strategic framework for the digital maturity of schools.
Cyprus	n/a
Czech Republic[C]	n/a
Denmark[C]	In 2022, the government released a new broad digital strategy which also includes its ambitions for the digitalisation of the education sector. The implementation of the strategy will be supervised by a digitalisation council composed of experts and representatives of the public and private sector.
Estonia[C]	Estonia's education digitalisation strategy is implemented through 3-year programmes and is monitored annually based on a set of indicators. In addition, Estonia has piloted a low-stake test of students' digital competence as part of quality assurance procedures. Previous evidence showed that the country also relied on schools' self-reporting on their digital technology infrastructure, surveys of students, teachers and parents in Estonian schools, as well as an annual report developed by a specialised agency. More generally, the strength of the Estonian monitoring and evaluation system lies in the Estonian Education Information System (EHIS) as Estonia has established and maintains a digital, online and encompassing information system that brings together data on schools, pupils, teachers, exams and qualifications.
Finland[C]	While there are no explicit monitoring and evaluation provisions in place, Finland has published a detailed description of digital and programming competencies foreseen for each age bracket as part of their New Literacies programme. These descriptions should inform the education providers to update their own plans and benchmark their students along the competence areas.
France	The French digital strategy for education sets out the commitment of collecting data on uses of digital technologies, training and equipment availability from actors of the digital education environment and establishing a shared indicator dashboard published by the Ministry of Education. Further, the ministry will carry out regular evaluations in co-operation with the Department of Evaluation, Forecasting and Performance.

Country/economy[1]	Monitoring and Evaluation Provisions for digital Education
	With respect to digital skills, France has developed a reference framework for digital skills (CRCN) organised in 5 domains and 16 skills. Students are tested on those skills through the Pix Certification of Digital Skills by an external provider.
Germany[C]	While there is no monitoring and evaluation of school digitalisation on a national level, federate state governments are responsible for reporting on the progress of Germany's flagship school digitalisation initiative 'Digipakt'.
Greece	Some aspects of school digitalisation are monitored through the national information system 'Myschool' which is run by the Ministry of Education. School principals regularly update information regarding schools' human resources and equipment in the system, in order to support schools accordingly.
Hungary[C]	Hungary's digital education strategy proposes the development of a measurement-evaluation and reporting system which can serve as the basis of policy decisions. It also suggests the creation of a Digital Methodology Centre tasked with tracking the achievement of the goals of the strategy.
Ireland	The implementation of Ireland's digitalisation strategy is supervised by a central stirring group. The objectives of the strategy will be further supported by an implementation plan running from 2022-2024. A midterm review will be carried out in 2025 to inform the next implementation plan.
Italy[C]	The two Italian digitalisation projects 'Next Generation Classrooms' and 'Next Generation Labs' set out in the Italian school digitalisation strategy entail monitoring of schools in 6-monthly cycles. Implementing schools will have to upload information on their progress through an online monitoring tool.
Latvia[C]	The two Latvian guidelines both set out the monitoring of digital skill levels in the population. Further, regular evaluations of the progress of the implementation of the strategies including an interim report of the education development guidelines are planned.
Lithuania[C]	The Lithuanian progress instrument 'Digital Transformation of Education' provides detailed elaborations on the targets of Lithuania's education digitalisation, building on the general educational development plan. The document is accompanied by a list of indicators that suggest the regular monitoring of the progress of school digitalisation.
Luxembourg	n/a
Malta	n/a
Netherlands	While there is no system-wide strategy in place, a range of actors are involved in monitoring and evaluating different aspects of digital education in the Netherlands. For instance, the Dutch Ministry of Education is responsible for monitoring and evaluating several long-term digital education programs that are part of the National Growth Fund – a public fund that invests in projects to ensure long-term economic growth (NWO, 2023[96]). In addition, several non-governmental organisations such as the Rathenau Institute – a technology assessment organisation – have published evidence on the state of digitalisation in the Dutch education system (Rathenau Instituut, 2022[97]).
Poland	Poland is currently in the process of developing a new strategy for digital competences. Once in force, the implementation of the strategy will be monitored by the Digital competence Development Centre.
Portugal[C]	Portugal launched an online platform at the end of 2021 to facilitate the gathering of information on the progress of digitalisation at schools. Through this online platform, digital ambassadors submit data on key indicators regarding the implementation of digitalisation policies at their schools.
Romania[C]	No monitoring and evaluation provisions
Slovak Republic[C]	The policies foreseen by the Strategy of the Digital Transformation of Slovakia is more closely specified in the corresponding action plan. The implementation of this action plan underlies annual reviews that will be submitted to the government of the Slovak Republic.
Slovenia	n/a
Spain[C]	In Spain, monitoring and evaluation provisions for education digitalisation are captured in the co-operation plans #EcoDigEdu and #CompDigEdu. While the provisions set out key indicators on which data should be collected, the task of raising the data lies with the autonomous communities.
Sweden[C]	The National Agency for Education conducts follow up studies on the implementation of the Swedish Digitalisation Strategy and the achievement of its goals every three years. The most recent report released in 2022 was based on a survey aimed at teachers and school heads and focused on the digital competences of all members of the school community, equal access and use of digital resources and general potential for digitalisation in schools.

Note:
[1] As part of the data gathering process, the OECD reached out to the national officials in the Eurydice country units of all EU member states and conducted background research on their monitoring and evaluation provisions. Superscript ''C'' in the country column indicates that the information displayed was obtained from national officials.
Source: Author's elaboration

Shaping Digital Education

ENABLING FACTORS FOR QUALITY, EQUITY AND EFFICIENCY

Investment in education technology has surged worldwide over the past decade and digital education technologies are now a key resource for OECD education and training systems. If used effectively, they promise to transform teaching and learning practices, to reduce learning inequalities and to create more inclusive and efficient education systems. However, countries' experiences during the COVID-19 pandemic exposed shortcomings in the extent to which digital technologies are currently enabling high-quality teaching and learning, and underlined the need for supportive policies and conditions to make use of their potential. The rapidly improving capabilities of Artificial Intelligence (AI) also bring new focus to the role of education policy in preparing learners for an AI-driven future.

This report seeks to guide governments in shaping digital education. Offering a range of perspectives for governments and education stakeholders, it analyses enabling factors that can support quality, equity and efficiency in the use of digital technologies in education systems. It provides a comprehensive review of current trends and emerging policies, covering school education, vocational education and training (VET) and higher education, highlighting pathways to support a cohesive and holistic policy framework for digital education.

Co-funded by
the European Union

PRINT ISBN 978-92-64-84671-5
PDF ISBN 978-92-64-75823-0

9 789264 846715