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Policies for the digital transformation of school education: State of play and key policy responses

16-17 March 2023, OECD Conference Centre, Paris, France.

This document is an annex to the Background Document "Policies for the digital transformation of school education: Draft analytical framework". It contains an assessment of the status quo in digital education policy in OECD countries to be discussed at the 8th Meeting of the Group of National Experts on School Resources (GNE-SR) on 16-17 March 2023.
The Group of National Experts on School Resources (GNE-SR) is invited to comment on the document and the assessment of the state of play in digital education policy.

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1 A strategic vision for digital education

This chapter overarches subsequent analyses in this document by underlining the importance of a strategic vision that encompasses all aspects of digital education. The effective digitalisation of education systems requires a coherent and coordinated strategy linked to concrete implementation instruments. In addition, digital education policies do not work in silos but require alignment with the broader policy ecosystem and accounting for the specific education governance environments within which they function. In this context, this chapter aims to guide education ministries in the design of a coherent strategic vision for digital education by reviewing existing evidence on high-level strategies for digital education in OECD member countries and identifying promising approaches.

State of play and challenges

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

1. The preparation of this document included taking stock of the current strategies for digital education across OECD and EU member countries, the results of which are presented in Annex 1.A[1]. The

[1] These efforts build on and update previous data collections focused on the existence of high-level strategies for digital education (van der Vlies, 2020[2]; European Commission/EACEA/Eurydice, 2019[5]).

analysis underlines the fast-changing nature of digitalisation policies, highlighting several updates since the beginning of the pandemic.

2. However, strategic activities in the field are not spread equally across countries. Rather, most strategic efforts on digital education are concentrated in European countries and OECD countries in Asia. On the other hand, digital education features less prominently in strategic government documents in OECD countries in Latin America. The governance arrangements of education systems are also reflected in the current provisions. A lack or lower role of central steering powers translates in some countries in guidance with a non-binding character (e.g. United States) or state-level strategies for digital education (e.g. Australia and Canada) rather than national-level ones.

3. 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. This is reflected in the types of technological uses they focus on (e.g. whether they contain clauses on advanced technologies), the areas covered and whether they are linked to specific implementation instruments. The subsequent chapters explore collected evidence on current high-level digital education strategies in OECD countries, illustrating how the landscape of digital education strategies has evolved in the recent years and how countries have designed their efforts and goals for digital education.

Less than half of OECD and EU countries had a specific strategy for digital education prior to the pandemic, with little progress made in recent years

4. Already prior to the pandemic, the vast majority of OECD and EU countries covered aspects of digital education either 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 1.1.

5. While broader strategies have the potential advantage of aligning policies for digital education with broader social and education goals, they often come at the cost of merely offering a brief and superficial discussion of issues specific to digital education. Up to today, only few countries have managed to provide a comprehensive discussion of digital education within their broader strategies. Germany can serve as an example of such an exception. While Germany also has a specific strategy for digital education, it has recently published an overarching strategy for the implementation of digitalisation reforms – a detailed catalogue of digitalisation initiatives planned across a range of policy areas including education (Die Bundesregierung, 2021[1]). Each initiative features a list of concrete goals and implementation steps.

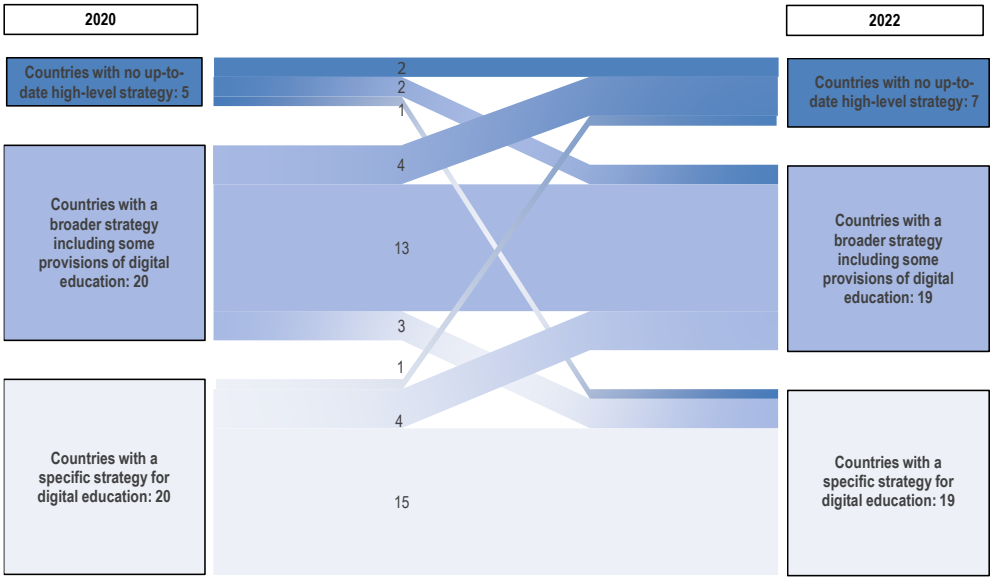
6. Another risk of including digital education in a broader strategy on digital innovation or skills in particular is related to a potential misalignment of goals: While digital education strategies should resolve around how digital technologies can support better *education outcomes*, broader strategies for digital innovation or skills usually discuss education as a means to other ends such as boosting digital skills for innovation or economic progress (van der Vlies, 2020[2]). 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, all 38 countries that replied to the OECD Digital Economy Policy Questionnaire had at least one type of Information and Communications Technology (ICT) education and training policy in place (OECD, 2017[3]). Yet, there are distinct ways in which digital technologies can enhance education outcomes (e.g. improving the quality of education provision through the use of learning analytics) which do not feed directly into the acquisition of digital skills. Considering digital education solely through the lens of digital skills is thus insufficient to unlock its full potential.

7. Despite the great advances in ICT usage in education throughout the pandemic, little strategic progress has been made on digital education across OECD and EU countries, as illustrated by Figure 1.1. Some countries – such as **Lithuania** - that did not have a strategy for digital education prior to the pandemic have now launched such strategies. Yet, others that had introduced strategic documents early on - have

not renewed their strategies upon expiration. However, the large investments in and use of digital technology in recent years call for the continuation of a coordinated 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 in order to ensure alignment with the latest state of technology and governments' strategic goals. The low activity across OECD countries with respect to renewing strategies for digital education is thus a cause for concern.

Figure 1.1. Existence of high-level strategies for digital education in OECD and EU countries, 2020 and 2022

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



Note: 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).
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.
Information on the existence of high-level strategies was collected from national administrative education units or through background research by the OECD. Annex 1.A provides further details on the strategies for digital education as well as information on the sources of evidence.
Source: Author's elaborations.

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

8. In most OECD and EU countries, digital education strategies revolve around ICT infrastructure and digital learning environments, whilst addressing challenges of fostering digital competence and bridging digital divides (van der Vlies, 2020[2]). Regarding ICT infrastructure, improving access to high-speed Internet connection and digital devices (e.g. computers) is at the core of many national digital education strategies. Discussions of digital learning environments focus either on easier access to quality learning resources or platforms (e.g. MOOCs, digital educational resources) for students and teachers, or on the facilitation of digital learning environments in schools and classrooms (e.g. through learning management and information systems). Digital education strategies also include a strong focus on managing the challenges associated with digital education, and in particular the development of digital competence (among students and teachers), bridging digital divides, and addressing privacy and security concerns.

9. In contrast, more advanced technologies such as Artificial Intelligence (AI) or Blockchain rarely featured explicitly in digital education strategies of OECD and EU countries and - when mentioned - they were addressed in rather generic terms. **Japan** represents an exception to this pattern. Its strategy for digital education focuses primarily on the use of *advanced* technology to support learning. Whilst the strategy also touches on more common issues such as the availability of hardware and teachers' digital skills, vast parts of the digital 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[4]).

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

10. Even among countries that feature strategies for digital education, there is significant variance 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, timebound policy measures for each of their broader goals (e.g. **French Speaking Community of Belgium**). In fact, digital education strategies often lack a concrete implementation roadmap (van der Vlies, 2020[2]), 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[5]). The monitoring and evaluation aspects will be covered in Chapter 7 of this document.

11. Systematic information on the governance structures responsible for monitoring the design and co-ordinating the implementation of digital education strategies, on the distribution of roles and responsibilities for implementation among the bodies or actors involved in such strategies or on co-ordination mechanisms was also 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. Indeed, the governance of national digital strategies has changed substantially in the past years. An increasing number of countries devote such responsibilities to a ministry, body or function in charge of digital affairs (Gierten and Lesher, 2022[6]). 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[6]; OECD, 2019[7]). The variability and evolution of digital strategies' governance arrangements also triggers questions about the extent to which digital education can figure as a top-level policy priority.

12. Moreover, little is known on the actual budgets associated with digital education strategies. However, some information is available about the funding of general digital strategies. For countries that

have a budget for their national digital strategy, its channelling can be part of a broader framework (e.g. United Kingdom) or decentralised (e.g. Austria). Budgets explicitly tied to national digital strategies can better support co-ordination and enhance accountability. In contrast, more decentralised funding may lead implementing authorities to simply repurpose existing funds and thereby result in underfunding of the strategy (Gierten and Lesher, 2022[6]). 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[6]). While this suggests that the majority of digital strategies lack sufficient backing with funding mechanisms, there are some positive examples for concrete resources tied to digital education strategies specifically:

- In **Germany**, the 'Digital Pact' provides three billion euros of federate 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.

13. 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, the nation's higher education institutional funding methodologies, regulation of educational offerings, academic career policies, and accreditation system have jointly limited the uptake of digital technologies in teaching and learning, and the expanded offer of hybrid and online study programmes (OECD, 2021[8]).

Key policy responses and promising approaches

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

14. 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 Recommendations of the Council in the area of public governance highlight a number of baseline enablers that can potentially be adapted to support governments in pursuing better policy design and implementation. Commitment, vision and leadership to enhance the sustainability of policies and reforms feature among these enabling factors (OECD, 2020[9])[2]. Commitment for reform at the appropriate political level can be expressed through a government vision, and evidence from OECD country reviews shows that governments with capacity to formulate, implement and communicate internally and externally a strategic vision are also more likely to enhance policy coherence (OECD, 2020[9]).

15. Such enablers do not represent by themselves a single or exhaustive recipe for sound public governance, and countries may have different rationales or objectives they seek to pursue in their digital education strategies. Commitment for digital education reform can vary, also depending on education systems' state of digital development, additional budgetary pressures or alternative reform priorities. In this respect, a strategy for digital education is not a necessary or mandatory condition and must-have 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, digital education has

[2] Other enablers are: equitable and evidence-informed policy-making, whole-of government coordination, and innovation and change management (OECD, 2020[9]).

implications for a range of policy areas, related to infrastructure and data privacy, human and financial resources, institutional capacity, educators' professional learning, etc.

16. A coherent and co-ordinated strategy for digital education can allow to address existing challenges in the area of digital education more efficiently, to better target resources to where they are most needed, and to ensure that policy efforts have mutually reinforcing effects. When underpinned by concrete implementation instruments, including funding and regulatory ones, such a strategy can increase countries' abilities of seizing 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 (see Box 1.1). The strategy puts forward a vision for digital education co-designed by the government with school leaders and teachers that addresses digital education challenges in New South Wales in an integrated manner and is underpinned by concrete implementation instruments.
- The Digital Strategy for Schools to 2027 in **Ireland** 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[10]). 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 and will support the preparation of a second implementation period.
- Similarly, the Programme of school informatisation until 2030 of the **Slovak Republic** evolves around strategic goals in five areas: i) ICT 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[11]). 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 time frame and funding channels (Ministry of Education of the Slovak Republic, 2021[12]).

Align digital education strategies to the wider policy ecosystem

17. Digital education strategies also need to be connected and aligned with the existing policy landscape. Strategies and policies for digital education cannot be conducted in isolation from policies outside of the education realm. Countries need 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[7]). 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[13]).

18. In this respect, 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 4). Co-ordinating education policies

with policies outside of the education realm also matters for building capacity for digital education (Chapter 5). 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, their connections with digital education policies and complementarities, is thus a 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, and social policies that bear on participation in/support for education and training.

19. Ensuring a coordinated policy approach for digital education also requires connecting digital education strategies to wider education system strategies and priorities. This is the case because the use of digital technologies is not an end in itself, but a means to educational goals. Some countries have thus chosen to integrate their digitalisation-related objectives in 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[14]).

20. Such example also highlights the importance of a coherent approach to digital education spanning several education levels. While 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). In this respect, each education level is a building block for subsequent ones in supporting individuals to seize the potential of digital technologies for learning while mitigating any 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**, the Digital Education Strategy has relied on a pillar structure following students' learning path from public education to higher education and adult learning, while a set of horizontal pillars span across the sectors of education (e.g. monitoring learning paths, accessibility for persons with disabilities, security) (Digital Success Programme, 2016[15]).

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

21. While digital education policies should be aligned with the wider policy ecosystem, digital education policies also require coordination between the different policy levers that underpin them and the different levels of policy intervention. There is a need to ensure that digital education strategies inform primary policy channels and communicate to the respective authorities (e.g. regulation of digital education technologies, resourcing arrangement, monitoring and evaluation mechanisms, etc.).

22. Especially in education systems that rely on the complex interplay between different levels of government, delineation of responsibilities is key for the successful implementation of digital education

strategies and the accountability of respective authorities. In **Switzerland**, the Swiss Conference of Cantonal Ministers (EDK) has delivered an example of such co-ordination effort. The EDK's 2018 digitalisation strategy did not only represent an effort to align the goals of different cantons regarding education digitalisation, it was also accompanied by an action plan that assigned responsibilities for each measure between the EDK and cantons and provided concrete time frames (EDK, 2018[16]).

23. Apart from accounting from the competencies of different levels of government, co-ordination efforts must also bridge the increasing complexity of wider 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, professional learning organisations, etc.) and multi-level decision-making processes with fluid links between actors at different levels increasingly characterise governance arrangements in OECD systems (OECD, n.d.[17]; Burns and Köster, 2018[18]).

24. 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 between the different levels of the system and authorities that best suits their context, but also reflect on how to strengthen co-ordination mechanisms and ensure that the different entities or levels in charge of digital education have sufficient capacity to deliver on their responsibilities (OECD, 2018[19]). Accounting for the governance arrangements of education systems in the planning and implementation of digital education policies also requires further consideration and understanding of decision making surrounding the use of digital technologies in education.

25. 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 1.1) or at lower levels of the system (e.g. by providing guidance, supporting platforms for collaboration or pooling of administrative resources across schools or municipalities, or regulating cooperation) (OECD, 2018[19]). In **France**, the Economic, Social and Environmental Council, a consultative assembly to the government and parliament, has advised for more co-constructed policy efforts for digital education between the central administration, local and regional authorities (Gariel, 2021[20]). In more decentralised education systems where the central level focuses more on setting the general goals and priorities for digital education, policy efforts should target building capacity at the lower levels of the system holding stronger responsibilities for planning and decision-making in the area of digital education.

Box 1.1. Coherent and co-ordinated policy approaches for digital education and skills: examples from OECD countries

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 results 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[21]). In addition, the Department of Education and the New South Wales Treasury 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[22]). 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 Schools Digital Strategy is specifically connected with 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 (seeking to lift education standards), 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[22]). Centred on an executive vision that describes its underlying hypotheses, the Strategy provides a detailed account of its governance arrangements, implementation details (e.g. actions, timing), pillars as well as immediate focus areas.

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[7]; Digital Skills and Jobs Platform, 2021[23]). The initiative is coordinated 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 (e.g. open data regulations), digital infrastructure investments and e-government (SMC, 2022[24]; OECD, 2019[7]). 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 partnerships, facilitating access to funding and enhancing the projects' visibility (Digital Luxembourg, n.d.[25]).

While at the time of its launch, digitalisation initiatives in Luxembourg remained relatively limited and scattered, the Digital Luxembourg initiative has resulted into a wealth of digitalisation-related projects underpinning a broader national strategy (Digital Luxembourg, 2020[26]). For instance, in the area of skills development for digital education, the initiative has enabled the transition from a handful of training opportunities for a selected public to comprehensive and broad trainings 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 ICT start-ups via the Digital Tech

Fund (a joint public-private partnership launched in 2016) (Trésorerie de l'Etat - Luxembourg, 2016[27]; Digital Luxembourg, 2020[26]).

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

26. Advanced technologies may increasingly permeate education systems and as new digital technologies become available to support learning and teaching processes, education systems need to be informed about technological evolutions and any 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 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 create the link with improvements in education outcomes.

- In **Switzerland**, Educa is the specialist agency for ICT 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.[28]). 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.
- Other countries, such as **Germany**, have designed their digital strategies as living documents that they update on a regular basis (Gierten and Lesher, 2022[6]).

Annex 1.A. High-level strategies for digital education

Annex Table 1.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 2023-2027** https://www.education.gouv.fr/strategie-du-numerique-pour-l-education-2023-2027-344263#:~:text=La%20strat%C3%A9gie%20num%C3%A9rique%20pour%20l,pour%20la%20r%C3%A9ussite%20des%20C3%A9l%C3%A8ves.	France released a new strategy for digital education in January 2023 which is built around 4 axes setting out the goals for digital education until 2027.
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**	Bulgaria's specific education sector strategy (strategy for the effective application of ICT in education) expired

	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	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-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/	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 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.
Columbia	**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	Columbia's broad digital strategy sets digitalisation goals and corresponding indicators on a quarterly basis, including some goals for the digitalisation of schools. The ministry of technology, information and communications also publishes progress reports tracking the performance along the indicators on a quarterly basis.
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-	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 coordinated with the European Framework for Digitally Competent Educational Organisations. The Framework covers five areas and five levels of the

	sazrijevanje-skola-i-skolskog-sustava-u-Republici-Hrvatskoj-2030.pdf	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 cyprian school digitalisation endeavors.
Denmark [C]	**Denmark's digitisation 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.
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 life-long 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	**Digital in the service of the school of trust (La numérique au service de l'école de la confiance)** https://cache.media.education.gouv.fr/file/08_-_Aout/36/1/DP-LUDOVIA_987361.pdf	The French specific strategy for digital education was released in 2018 and provides a comprehensive discussion of a range of areas of digital education.
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**	The greek 'digitalisation bible 2020-2025' exemplifies a broad digitalisation strategy with substantive provisions

	https://digitalstrategy.gov.gr/	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**	The 'Iceland Education Policy 2030' covers digital education as part of its third pillar on skills and future.
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** https://pnrr.istruzione.it/wp-content/uploads/2022/07/PIANO_SCUOLA_4.0_VERSIONE_GRAFICA.pdf	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 focused on digital classroom infrastructure and fostering key digital skills.
Japan	**Promoting measures to utilize 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 coordinate 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		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	In 2019, the Netherlands released its first specific strategy for digital education, aiming to set the course of digitalisation in education.
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/ **Digitalisation strategy for the higher Education Sector 2017-2021 (expired)** https://www.regjeringen.no/en/dokumenter/digitalisation-strategy-for-the-higher-education-sector-2017-2021/id2571085/?q=ict&ch=2#match_0	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.
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 Slovenia 2030 (forthcoming)** https://www.gov.si/en/topics/digitalisation-of-society/ **Digital Education Action Plan 2021-2027** n/a	Slovenia's previous broad strategy (Digital Slovenia) expired in 2020. A new national digitalisation strategy is under development at the time of the writing of this document.
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 between 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/uploads/system/uploads/attachment_data/file/791931/DfE-Education_Technology_Strategy.pdf **UK digital strategy**	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'. 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.

	https://www.gov.uk/government/publications/uks-digital-strategy/uk-digital-strategy#s3	
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[2]) was used as a starting point for further enquiries.

2 Adapting pedagogical approaches, curricula and assessments to digital education technologies

This chapter focuses on adapting pedagogical approaches, curricula and assessments to make the most effective use of digital education technologies for teaching and learning. It takes stock of the take-up and use of digital education technologies and presents strategies to overcome barriers that have so far limited their effective use for teaching and learning. The chapter also acknowledges the importance of adapting curricula for digital education as well as the general implications of digital technologies for assessment practices and credentialing.

State of the play and challenges

27. Whether digital education technologies can deliver on their potential to enhance teaching and learning depends on their 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 schools 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 in practice 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

28. Data systems trail behind policy and practice. Administrative data collections have been slow to keep up with the technological progress in schools, and information on the take-up and use of digital education technologies at the institutional or national level remain the exception. 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. Likewise, 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 information on the frequency with which teachers use computers in primary schools.

29. 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[29]) have advanced our understanding on 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 ICT remains rudimentary. 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 ICT into pedagogical practices and learning environments (OECD, 2019[30]).

Which digital technologies are used in instruction and how has their use evolved?

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

31. Another 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 2.1 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 about 15 years ago 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 is 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 solutions (Molenaar, 2021, p. 60 ff.[31]).

Table 2.1. Personalised learning technologies of different degrees of automation

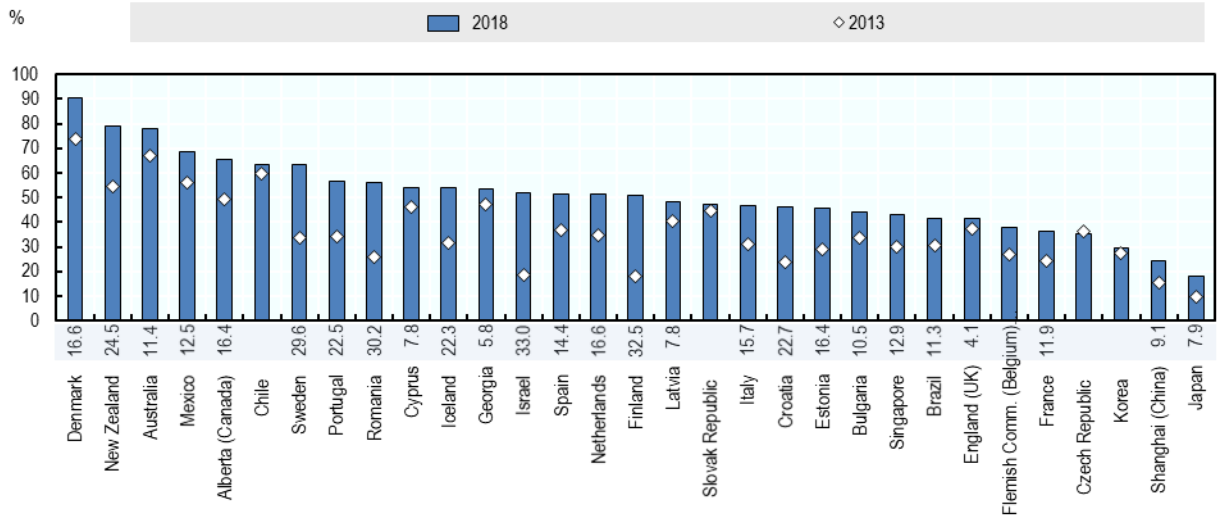
Level of automation	Distribution of control and functions of technology	Examples of technologies
Level 0 (Teacher only)	Teacher controls	Technologies that are fully teacher controlled, without organizing function
Level 1 (Teacher assistance)	Teacher has full control; Technology provides supportive information (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) 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) 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) 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)

Source: Molenaar (2021[31]), "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.

32. Despite rapid advances on the "possibility frontier" of 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 study, only 53% of teachers reported frequently letting students use ICT for projects or class work in 2018 (OECD, 2019, pp. 205, Table I.2.4[32]). Nevertheless, this constitutes a significant rise from just 38% of teachers who reported doing so in 2013 (OECD, 2020, p. 36[33]). 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 2.1). 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.

Figure 2.1. 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



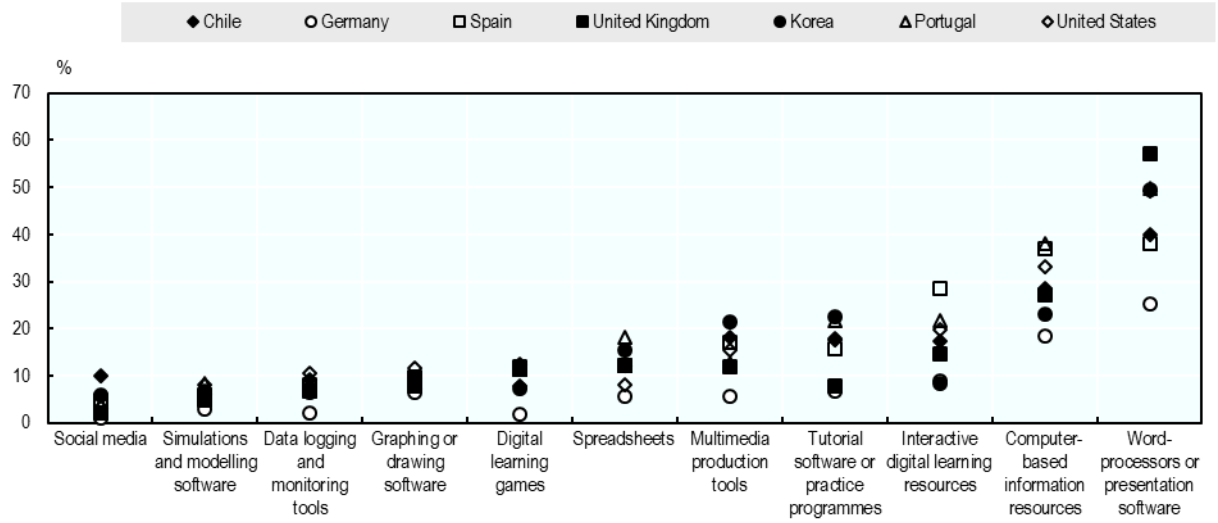
Notes: These data are reported by teachers and refer to a randomly chosen class they currently teach from their weekly timetable; Only countries and economies with available data for 2013 and 2018 are shown; Countries and economies are ranked in descending order of the percentage of teaching practices pertaining to clarity of instruction in 2018; 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[32]), TALIS 2018 Results (Volume I): Teachers and School Leaders as Lifelong Learners, https://doi.org/10.1787/1d0bc92a-en, Table I.2.4.

33. 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 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 though, 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 (Sutcliffe, 2021, p. 2[34]).

34. 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, which 44% of teachers in participating countries reported using 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 2.2.). International comparative evidence on the use of digital learning technologies for specific students groups is even more limited. Most international data collections, for example, do not cover the use of assistive technologies.

Figure 2.2. Teachers' use of digital tools (2018)

Proportion of 15-year old students' teachers reporting to use 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: Author's calculations based are based on data from OECD (2018[35]), PISA Database 2018, https://www.oecd.org/pisa/data/2018database/

35. Besides their use in general education, digital technologies are already widely used in the Vocational Education and Training (VET) sector. In the six OECD countries and regions with available data from the 2018 TALIS survey, [3] 74% of upper secondary VET teachers reported using digital technology with their students, compared to 66% of general education teachers (OECD, 2021, p. 131[36]). Data from the European Commission's SELFIE further suggests that VET teachers are slightly more likely than general education teachers to report using digital tools for teaching (OECD, 2021, p. 132[36]; Hippe, Pokropek and Costa, 2021[37]). Although comparative international data on the use of specific digital education technologies is limited, examples for the use of advanced technologies in VET include the following (OECD, 2021, pp. 135, Box 4.8[36]):

- **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[38]).
- **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

[3] 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[36]).

operate more than 20 different vehicles to perform complex loading tasks and deliver a variety of cargo directly to customers (Simula Games, 2022[39]).

- **Use of simulators and virtual reality in the health sector**: Labster Labs promotes scientific learning by making online education modules available to VET teachers using desktop simulations and 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[40]).

How are digital technologies used?

36. As described in the analytical framework [EDU/EDPC/SR(2023)2], 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 educational outcomes (Bulman and Fairlie, 2016[41]; Minea-Pic, n.d.[42]). What matters for student learning is whether learning technologies are adapted to a given context and how they are 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.

37. Results from PISA 2018, for example, 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, p. 55[43]; OECD, 2021[44]).

38. So far, most 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. Evidence from video observations conducted for the TALIS Video Study, however, suggests that – at least prior to the COVID-19 crisis – relatively few of the participating teachers used technology in innovative ways and most let students make little use of it in the classroom (OECD, 2020, p. 115[45]).

39. 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 in two lessons covering quadratic equations in secondary school mathematics. The video material was coded following common and standardised protocols and complemented with the lessons' teaching materials. As can be seen in Table 2.2Table 2.2. , teachers in most observed classrooms made some use of technology, but primarily for communication purposes, for example using power point slides, overhead projectors or document visualisers to convey information to the class (OECD, 2020, p. 115[45]).

40. Only a relatively small proportion of teachers made use of technology to promote students' conceptual understanding in their classes, that is, to aid the analysis, evaluation and creation of work or to focus on the underlying logic of procedures and processes. 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[45]). The use of technology was also rarely integrated into teaching materials in order to develop students' understanding of mathematical concepts and relationships, to make and test conjectures, look for patterns, and develop understanding of mathematical concepts and relationships. Nevertheless, the TALIS Video Study finds that one in five teachers in Germany and one in ten teachers in Madrid (Spain) make some use of technology in teaching materials as a tool to make computation or graphing more efficient (e.g. calculators), 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, pp. 242, Table 5.B.21[45]).

Table 2.2. 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

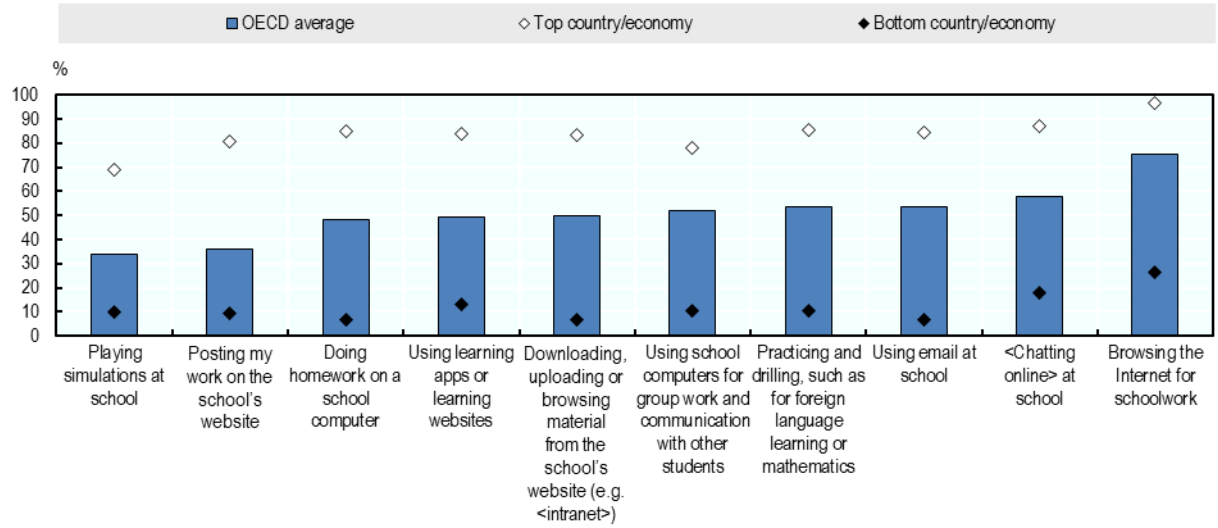
Country	Number of classrooms	Percentage of Classrooms with Highest Rating for			
		No Technology Used	Communication Only	Communication + Limited Conceptual Understanding	Communication + Conceptual Understanding
B-M-V (Chile)	98	42.9	43.9	8.2	5.1
Colombia	83	50.6	22.9	12.0	14.5
England (UK)	85	0.0	55.3	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[45]), *Global Teaching InSights: A Video Study of Teaching*, https://doi.org/10.1787/20d6f36b-en, Table 5.1.

41. 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, p. 131[44]). 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 2.3.). 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, p. 130[44]).

Figure 2.3. 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[44]), *21st-Century Readers: Developing Literacy Skills in a Digital World*, https://doi.org/10.1787/a83d84cb-en, Figure 6.12.

42. As can be seen in Figure 2.3. , 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, p. 130[44]). 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, p. 132[44]).

43. 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[46]). At the same time, the heterogeneity across countries suggests that the way in which students use digital devices and how their use is embedded in the learning process may matter more for their outcomes than whether and for how long students use them (OECD, 2021, p. 132[44]). 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, p. 132[44]).

44. In addition to general surveys investigating teachers' use of digital education technology across a range of devices and software, several evaluations have taken a more fine-grained approach studying teachers' use of specific software or digital devices. These studies provide us with a better

understanding of teachers' different ways of interacting with technology as well as the extent to which they exploit the full range of functionalities offered by specific devices. Evaluations of the Learning Management System (LMS) Blackboard Learn (Whitmer et al., 2016[47]), for example, 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 and the experience of higher education suggests 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[48]).

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

Despite their promise to enhance educators' work, digital education technologies may be maladapted to their needs and priorities, making their use unattractive

45. Although digital education technologies can enhance teaching and learning in principle, evidence suggests that – even where they are available – not all educators use them to their full potential. As discussed above, in-depth studies of individual learning technologies have shown, for example, that users of learning management systems 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[48]; Whitmer et al., 2016[47]; Bond et al., 2020[49]; Price and Kirkwood, 2011[50]). 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 6, which focuses on capacity-building, surveys of educators and school leaders expose significant deficits in their preparedness to support digital learning (OECD, 2022[51]). Besides the lack of capacity, training and support, another factors that may explain this under-use of available digital technologies in schools is that they are insufficiently adapt to teachers' needs and priorities.

46. Not all digital education technologies are developed drawing on the expertise and involvement of educators and other stakeholders (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. Given the proliferation of different technology providers and tools, schools may also struggle to select the most suitable or effective technologies from an ever expanding pool of suppliers. Finally, in the absence of a conducive legal framework and standards on openness and interoperability, the effective use of education technologies may be undermined by their lack of compatibility (OECD, 2021[52]). Anecdotal evidence suggests that both student and educators can be frustrated by 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

47. 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, pp. 239, Table II.5.32[33]). 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 use ICT and are more likely to revert to the more conventional approaches of "chalk and talk" pedagogy (Gil-Flores, Rodríguez-Santero and Torres-Gordillo, 2017[53]). This is corroborated by evidence from ICILS, which shows that teachers who were confident about their own ICT capability were more likely than

their less-confident colleagues to emphasise developing their own students' ICT skills (Fraillon, Schulz and Ainley, 2013, p. 217[29]). A lack of guidance, professional exchange or accessible evidence on "what works" with respect to digital education technologies may contribute to educators' reticence.

Institutions' and educators' autonomy disperse decisions about the take-up and use of digital education technology, limiting the steering role of central authorities

48. Schools in most European countries have significant leeway in shaping the way their educators deploy some types of ICT resources. While the procurement of connectivity infrastructure, cloud services and other resources that are best provided at scale tends to be more centralised, schools – even in otherwise more centralised systems – are often responsible for selecting, purchasing and maintaining other types of ICT resources (European Commission, 2013[54]), as well as designing guidelines, training, supports and incentives for their teachers, and assessing and evaluating their use of ICT (OECD, 2019, p. 32[30]). Likewise, at the level of tertiary 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.

49. At the same time, institutions' autonomy limits the steering role of central authorities and their ability to increase the take-up and effective use of digital education technology. 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 ICT resources for instruction, such as requirements to obtain permission from legal guardians or principals, the need to supervise students, safety and privacy regulations, restrictions to the access of specific ICT functionalities and the Internet, or limits on the time students can spend using ICT resources in schools. Central authorities may also specify conditions under which ICT should not be used, notably with regard to equity issues in the classroom, for example if some students do not have ICT resources at home or lack the basic ICT skills necessary to use them (OECD, 2019, p. 19[30]).

The use of digital education technologies needs to be reflected in curricula and assessment frameworks

50. Given the expansion of digitalisation in all areas of life, 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, p. 49[55]). Over the past decades, many OECD school systems have therefore 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 and practical skills (OECD, 2020[56]). These curricula reforms have integrated skills and content related to information and communications technology (ICT), either by creating new subjects (as was the case in Australia, British Columbia, Denmark, Ireland, Kapan, 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 that responded to the Education 2030 Policy Questionnaire on Curriculum Redesign) (OECD, 2020, pp. 51, Table 3[56]).

51. Aligning evaluation and assessment frameworks with students' learning objectives is a hallmark of successful education systems (OECD, 2013[57]). As education systems increasingly integrate digital skills into their curricula, assessment practices may need to be adapted in order to ensure that they remain fit for purpose. 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[58]). 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[59]) 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, p. 16[52]).

Key policy responses and promising approaches

52. Governments can support the use of appropriate and impactful digital education technologies throughout the entire process of their development, their selection and their integration into teaching and learning. This dimension considers policies that can be implemented at each of these three stages, focusing on strengthening interactions between educators and the EdTech sector; supporting teachers and schools in selecting technologies that are suited to their needs; spreading good practices for digital teaching and adapting curricula and assessment frameworks for the digital age. There are other important policy levers to support the effective use of digital education technologies that are addressed under other dimensions of the analytical framework: Policies that support the digital capacity of students, teachers, schools and other actors in the education ecosystem are the focus of Chapter 6. Guidance and regulatory frameworks for digital education are the subject of Chapter 3.

Support schools and teachers in selecting digital education technologies

53. Given that schools and teachers in most education systems are given some leeway in choosing which digital education technologies they use, strategies supporting them to make informed choices are an important part of ensuring the effective use of digital education technologies. Indeed, institutions and educators may be expected to identify, assess and select ICT 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 adapting available resources to fit their needs or creating new digital resources themselves. In addition, education institutions and educators may need to manage and maintain digital resources, share them with their students, while maintaining up-to-date knowledge regarding the potential risks involved in sensitive digital content and copyrights (OECD, 2019[30]; Redecker, 2017[60]).

54. When selecting digital education technologies, schools and teachers may also require support to ensure the interoperability of various tools (i.e. the ability of selected computer systems or software to exchange and make use of information from other systems or software). Given that education institutions in some systems have already widely adopted LMS (Brown, Millichap and Dehoney, 2015[61]), 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.

55. The move to digitalisation in teaching and learning involves organisational change and high costs for institutions, meaning that institutions face risks and can benefit from advice and experience of others. Clearinghouses or certification mechanisms can be useful levers for governments to reconcile institutional autonomy in the selection of educational technology with some degree of quality assurance and accountability on public spending. In this context, National Research and Education Networks (NRENs) and cooperatives are ways in which countries have centralised information on resources and more importantly on “what works” for educators and institutions. For instance:

- In the **United Kingdom**, the NREN Jisc 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 implementation projects and draw attention to potential pitfalls (JISC, nd[62]).

- 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 showcasing 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 means that suppliers are influenced by the needs of educators, education managers and institutions (British Educational Suppliers Association, nd[63]; LendED, 2022[64]; OECD, 2021[8]).

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

56. 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 schools, teachers and students in mind. Accordingly, a first strategy for policymakers is to promote educators' involvement in the development of digital education technologies during the R&D process. This can be achieved through user-driven innovation, which places the final user of a particular product or service at the core of the innovation process in a systematic way, for example by engaging educators, learners and staff in the analysis of a specific educational problem and the design of possible solutions (European Commission, 2020[65]). 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, p. 123[66]).

57. 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[31]). 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, p. 34[52]). 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 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, p. 29[52]). Several successful examples of educators' engagement are presented below.

58. One challenge faced by education authorities is to determine what role they can and should play in fostering these forms of collaboration. Education ministries can 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, p. 4[52]). 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 techniques or discoveries in the field of education technology become or remain a public good to allow actors internationally to develop new interoperable solutions that will help improve education (OECD, 2021, p. 37[52]). To achieve this, research and development projects in this area should build on public-private partnerships between government, technology researchers within universities and companies, and the education technology industry. This would also help to clarify which social and legal adjustments are required for the widespread adoption of promising technologies (OECD, 2021, p. 29[52]).

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

- The EDUCATE project, hosted by University College London's 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, p. 37[52]; Cukurova, Luckin and Clark-Wilson, 2018[67]).[4]
- 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 educational 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, p. 37[52]).[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 4 and 7 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[66]; Frauenberger, Good and Keay-Bright, 2011[68]). A small-scale (n=15) evaluation of ECHOES in 4 UK schools (without control group) has focused on its ability to support neuro-diversity, i.e. the acceptance of neuro-atypical people. It found children to engage with the environment, progress through different learning activities and positively change their behaviour towards human partners whilst in the environment (Porayska-Pomsta et al., 2018, p. 29[69]).

60. Some OECD countries have invested in platforms that allow teachers' 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 learning management systems (*espaces numériques de travail*) where the BRNE are deployed. School learning management systems 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 learning management

[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).

system), 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[70]).

Spread good practice and innovations by facilitating peer learning

61. Given their limited ability to steer the use of digital tools directly in the context of institutional autonomy, a third strategy used by governments has been to rely on incentives, information initiatives and dialogue to encourage schools to adopt institutional digitalisation strategies in ways that enhance digitalisation (Van der Vlies, 2020[71]). Capacity building and training are an important dimension of this, which is the focus of Chapter 6. Fostering professional collaboration is also important since it has been shown to be positively associated with teachers' sense of self-efficacy (OECD, 2020, pp. 66, Figure II.1.8[33]) and their openness to using ICT in the classroom (Gil-Flores, Rodríguez-Santero and Torres-Gordillo, 2017[53]; OECD, 2022[51]). 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, to inform practice and the ongoing development of digital education technology:

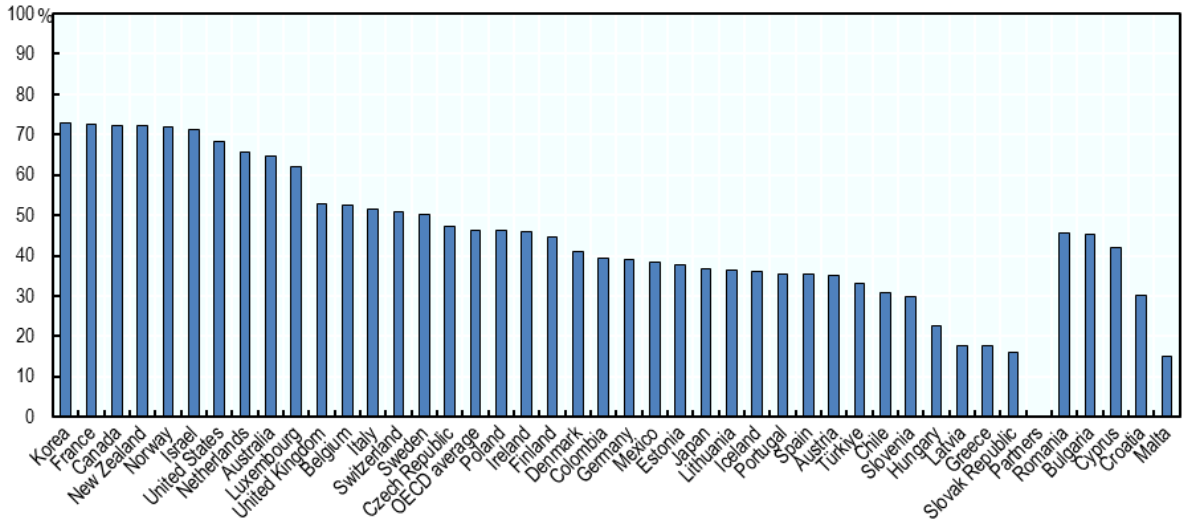
- The *Enlaces* programme in **Chile** aimed to develop teachers' ICT skills and promote teachers' attitudes conducive to the use of ICT in classrooms. In 2018, the programme gave way to a new Innovation Center at the Ministry of Education, which broadened its mission to explore new teaching methodologies, 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, p. 58[32]).
- As part of a national ICT programme, Adapting the Educational 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, p. 58[32]).
- As part of its 8-Point Plan for Digital Learning, launched in June 2020, **Austria's** federal government pursues a range of initiatives that aim to improve the use of digital technologies in teaching and learning, develop digital skills and awareness among young people, and promote interest in technology and technological development. One of the Plan's measures includes the alignment of digital resources that have been made available through the *Eduthek* platform 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 Plan is also an example of efforts 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. Overall, the government has committed to investing EUR 200 million to support the Plan until 2022 (Federal Ministry of Education, 2020[72]; OECD, 2021, p. 148[73]).

62. 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. Many schools in OECD countries devise written statements, programmes or policies to this end. In 2018, before the pandemic, 62% of 15-year-old students on average across OECD countries already attended schools that had written school statements about the use of digital devices, although only 46% of students

attended a school with a written statement specifically about the use of digital devices for pedagogical purposes (see Figure 2.4). To support the use of digital technologies outside of school, many governments have distributed devices to students for educational use at home, particularly during the COVID-19 pandemic when physical access to education institutions was limited (OECD, 2021[74]). 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 2.4. 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[75]), *PISA 2018 Results (Volume V): Effective Policies, Successful Schools*, https://doi.org/10.1787/ca768d40-en, Table V.B1.5.18.

63. Yet, 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, p. Table V.B1.5.20[75]). Public authorities should also be attuned to potential inequities arising from socio-economic differences in schools' capacity to promote the use of digital education technologies. Principals' reports in PISA 2018 suggests 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[76]; OECD, 2020[75]). These differences in capacity should be addressed in order to avoid the risks of exacerbating existing digital divides.

Adapt curricula to recognise the use of digital education technologies

64. Adapting curricula at different education levels to recognise the use of digital education technologies can support their integration into teaching practices. Curricula can not only promote students' acquisition of ICT skills (e.g. by making explicit reference to competencies, such as computational thinking, within the mathematics curriculum), they can also make reference to the use of ICT as a means of helping students acquire a more general range of knowledge and skills (OECD,

2019, p. 19[30]). Several countries have developed system-level guidelines or adapted their curricula to support the integration of digital education technologies into the teaching process. There are different approaches to integrating ICT skills into curricula. Traditionally, many countries have taught digital skills primarily in dedicated ICT or computational science classes (see the example of France below). Other countries have moved away from stand-alone ICT classes and adopted a cross-curricular approach to ICT 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[7]). Several recent examples of these different approaches are provided below:

- In **Israel**, the 2007 national programme, *Adapting the Educational System for the 21st Century*, included a curricula reform that strengthened the link between competency-based learning goals, innovative pedagogies and the use of ICT 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 ICT 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, p. 58[32]).
- In 2019, **France** introduced mandatory courses on computational sciences and technology in secondary schools with the objective of teaching ICT as a science but also of discussing the role of digital technologies in society (Ministère de l'Éducation nationale, 2019[77]). The government also encouraged the creation of extra-curricular coding workshops and will progressively introduce a certification of digital skills for students in their last secondary school year (OECD, 2019, p. 188[7]).
- Between 2012 and 2016, **Estonia** implemented the ProgeTiger programme, aimed at preschool, primary and vocational education students (Education Estonia, 2021[78]). 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 ICT infrastructure acquisition by schools (Redecker et al., 2017[79]). 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 benefited from the support of local networks related to the programme (OECD, 2019, p. 188[7]).

3 Guidance and regulatory framework for digital education

This chapter examines the provision of guidance (e.g. through standards – including minimum standards where relevant, guidelines, and recommendations) 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 as they make investment decisions in digital education infrastructure, or seek to comply with existing digital security and data protection frameworks. Quality standards and guidelines for digital education can also support institutions in making effective use of digital technologies that translate into better student outcomes. As educational technologies constantly evolve and new tools emerge, continuous regulatory efforts are also required to ensure digital learning environments respect the privacy of learners and avoid inequitable practices (e.g. algorithmic bias).

State of the play and challenges

Efforts to design and implement regulations and institutional capabilities that permit the protection of learners and avoid inequitable practices in digital learning environments remain insufficient

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

65. A rise in the use of digital technologies in learning processes also triggers an increase in the associated risks students are likely to face while going online (at school or at home) for learning activities. The COVID-19 pandemic has substantially increased the amount of data shared in educational settings, translating into heightened privacy risks for students (OECD, 2021[80]). Before the pandemic, responses from 34 countries to an OECD Policy Questionnaire on the protection of children online in 2017 revealed a wide variety of online risks faced by children and considered to be relevant by policymakers (e.g. bullying, online privacy, hateful content, harmful overuse of connected devices and online services, Internet addiction) (OECD, 2020[81]).

66. While the survey did not cover risks associated with digital education per se, students are also likely to be confronted with such risks when using digital technologies for learning, particularly if learning activities take place at home or are unsupervised by a teacher or adult. Indeed, as children get older, parents' awareness on their children's online activities tends to decrease (European Commission, 2019[82]). Educational software or digital education platforms that reach students through schools may be subject to tight data protection or privacy regulations that may help prevent a number of risks, especially if their developers follow principles of safety by design (UNICEF, 2022[83]). At the same time, such built-in protections may not always be sufficient and students may, for instance, still be vulnerable to cyberbullying through e-learning platforms or to a variety of online risks (e.g. harmful content) when looking for information on line for school work. The collection, use and reuse of children's data from such platforms may also be problematic for children's privacy (OECD, 2022[84]). In addition, children may also be exposed due to their own conduct, if they disclose personal information unintentionally during learning processes, share or upload inappropriate content, infringe on copyright or other rights through plagiarism, etc. (UNICEF, 2022[83]).

67. This wide variety of risks that children potentially face in a digital learning environment raises the need for a coordinated 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[81]; Burns and Gottschalk, 2019[85]). 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 for public awareness promotion regarding the processing of children's personal data (OECD, 2020[81]).

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

68. 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 to become a key challenge, given the reported significant and rising incidence of cyber-attacks, most often ransomware and distributed denial of service. And educational institutions are not immune to cyber-attacks. For example, using phishing emails and stolen credentials to access IT networks, criminals leverage ransomware to

steal sensitive information and block access to essential data and systems through encryption, demanding payment in exchange for returning access to the targeted institution.

69. Cybersecurity risks have rapidly expanded in education systems. This is 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. This proliferation of accounts drives an increase in data breaches and a surge in threats targeting vulnerable websites.

70. 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 around up to date operating systems and software and anti-virus software, but also more sophisticated tools such as Multi Factor Authentication (MFA), Virtual Private Networks (VPNs), end-user device management and remote wiping.

The enforcement of data protection regulations likely varies across education institutions falling under the General Data Protection Regulation

71. The increased use of digital technologies in education raises concerns about the protection of data collected during educational processes. Data protection in education institutions is no longer a choice but a necessity. 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[86]).

72. The GDPR considerably raised the level of accountability for 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 GDPR;
- employ or assign a Data Protection Officer with a comprehensive knowledge of new data protection law to liaise with the ICO.

73. While the mandatory nature of GDPR standards makes progress on data protection in education institutions continuous, there are no system-wide statistics on the level of adoption across countries. Enforcement of GDPR has likely varied across EU countries due to differences in the human, financial and technical resources devoted to enforcement (Ruohonen and Hjerppe, 2022[87]).

74. 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.[88]).

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

75. Interoperability is the ability of two or more systems (or components) to exchange information and use that information 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 and encourages continuous quality improvements by lowering the risk of provider lock-in, and allows for better monitoring of data and systems.

76. Education data and systems operate within general interoperability frameworks, including the European Interoperability Framework (European Commission, 2022[89]) 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[90])). Institutions may complement these broader frameworks with one of the multiple public and proprietary interoperability standards and frameworks for education. Progress in the implementation of interoperability frameworks has been however 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[52]).

Addressing algorithm accuracy and bias requires further research and regulatory efforts

77. While digital technologies hold great potential for supporting more effective learning processes that translate into more equitable learning outcomes, algorithm accuracy and bias remain key concerns. Evidence on smart technologies, including early warning systems, classroom analytics or other AI-powered tools, shows that algorithm accuracy is not fully guaranteed yet (OECD, 2021[52]). In addition, many concerns remain about the potential bias of algorithms which in turn 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[91]). However, 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.

78. Whenever high-stakes decisions on students (or teachers) are made on the basis of potentially inaccurate or biased algorithms, the use of digital technologies may lead to equity issues and unfairness in students' opportunities and outcomes. Regulations on the use of algorithms and AI may then be desirable to address these issues. Yet, most OECD countries continue lacking regulations for algorithms (OECD, 2021[52]), although a number of countries are increasingly considering regulations to enhance the transparency and accuracy of automated decision-making systems (Casovan and Shankar, 2022[92]). While the GDPR put forward an ambiguous approach to algorithms in the EU (OECD, 2021[52]), more recent efforts seek to design legislation targeting AI use in high-risk fields (e.g. board control). However, the use of algorithms in education does not seem to be the object of such regulations yet.

Quality assurance is not yet fully adapted to digital education

79. While evaluation and assessment tools have expanded and diversified in school education, they are not always tailored to digital education. Quality assurance policies and practices have become increasingly varied in school systems, including school self-evaluations, external school evaluations, national examinations, teacher 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).

80. 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[5]). Some countries had adopted a mix of evaluation methods and

data sources (e.g. surveys, classroom observations), building a comprehensive approach to quality assurance for digital education. In **Estonia**, broader surveys on well-being at school included questions targeted to students, parents and teachers on the use of digital devices for learning, guidance received by students from teachers in this area from teachers, 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[5]). 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 true 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. A number of questions thus emerge, regarding the design and areas to be covered by such evaluation frameworks and tools (e.g. focus on quality of digital infrastructure, teachers' and school leaders' preparedness to work with digital technologies), as well as the ways of using the results of such evaluations (e.g. for identifying and promoting good practices).

81. 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[93]). The new accreditation aims at increasing standards of full-time online education, while also better-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 services 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 better assessing and certifying their quality. At the same time, 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.

Key policy responses and promising approaches

Establish and ensure the implementation of a regulatory framework to guide digital education, and adapt it to evolving needs

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

82. Education institutions across OECD countries face increasing challenges in ensuring the security of their activities online, but also in complying with regulations aimed at supporting the privacy of their learners' data. Institutions, school leaders and teachers may be insufficiently prepared to adapt to evolving technology trends as well as rising regulatory demands. In addition, while the regulatory framework might be present, compliance with its requirements often triggers additional resource needs. Additional funding and training are required to ensure a proper implementation of laws and regulations. In this context, some countries provide support in the shape of guidance for education institutions, teachers and learners, as well as 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[81]). In addition, the national data protection authority developed a reference framework for the training of students specifically devoted to data protection (Eduscol, 2022[94]). The framework is intended to be used as part of school courses as well as in the training courses of educational staff, regardless of the subject taught with the aim of building a common base of concrete skills in the field of personal data protection. It was also adopted at the international level by all data protection authorities in 2016.
- 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[95]) 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, effectively detect, manage and solve any incidents (NCSC, 2021[96]).

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

83. Countries have often relied on multi-layered legal and policy responses to support children's protection in digital environments. While such efforts are not focused on digital education per se, they also address risks stemming from children's engagement with digital education technologies since many of these risks are common to the more general risks to which children are exposed in digital environments (e.g. cyberbullying, data privacy-related risks). Such legal and policy responses have included the adaptation or creation of new laws to address emerging risks, the design of codes of compliance with existing frameworks, educational and awareness-raising initiatives, etc. Regulations have targeted the providers of digital technologies, services or content, and 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 and transparency, establish safeguards and take precautions regarding children's privacy and data protection, and demonstrate accountability (OECD, 2021[97]).

84. Efforts for international cooperation or co-ordination regarding standards-setting for digital education technologies, particularly in areas related to 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[81]). At the national level, coordinated and targeted approaches for children's protection in digital environments are not widespread yet, although a few OECD countries have accompanied more targeted legislation with the establishment of statutory oversight bodies for online privacy protection (OECD, 2020[81]). As of 2017, in **Israel** and **Japan**, these bodies were specifically targeted at protecting children whereas in other OECD countries they were wider in scope.

85. Further cooperation at the national level should accompany international cooperation efforts on children's protection in digital learning environments. Education authorities should be engaged in any regulatory efforts or discussions at the government level on children's protection in digital environments to ensure any risks or concerns related to the use of digital technologies in education are taken into consideration in the design of further legal or policy responses. In this respect, designing an appropriate framework of law and regulation to guide a safe use of digital technologies in learning processes also requires cooperation between a variety of stakeholders with roles in protecting children and mitigating any risks they may incur. 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 responsibility for education, child protection, social services, etc. (UNICEF, 2022[83]).

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

86. Given the complexity and increasing importance of data standards, previous OECD work has made a number of recommendations to be implemented at the national level, including: designating a group of experts to assess, compare and suggest ways of improving existing government and institutional ICT and data policies and standards, including those related to the standards for personal data protection and use, the sharing and use of content, as well as integrity of data in a digital learning environment (OECD, 2021[8]).

87. Networks and associations can provide an effective vehicle to ensure compliance with data protection frameworks and advocate for data protection rights of education institutions. In **the Netherlands**, SIVON (a cooperative 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[98]). In addition, such networks, associations and cooperatives have also emerged as providers of security services for education institutions. SIVON provides secure Internet services to schools. It centralises calls for tender and manages contracts with security service providers in compliance with European and National security legislation. Schools that contract out their security services to SIVON join the National Services Center (NDC) – a service dedicated exclusively to education – that provides them with a dedicated firewall, and offers schools the choice additional security measures according to their needs. The Dutch Ministry of Education, Culture and Science (OCW) has provided a subsidy for schools to join the NDC for the period 2019-2023.

Support the development of policies, standards, or guidelines when they are not available

88. Regulations surrounding the use of algorithms and AI have been less widespread in OECD and EU countries. While there have been occasional efforts to regulate their use more broadly (e.g. the Algorithmic Accountability Act of 2022 proposed in the **United States**), legislation, guidelines and standards specifically for the education sector remain scarce. However, education marks a critical area of application for AI and algorithm-based tools, with a 36% estimated growth in the size of the education AI market between 2022 and 2030 (Grand View Research, 2021[99]). Against the background of growing concerns on the impact algorithm bias in education, the large expected uptake of these new technologies must be matched by new regulative efforts.

89. While regulations of AI and algorithm-based tools exceed the scope of 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[91]; Turner Lee, Resnick and Barton, 2019[100]; OECD, 2021[52]). Considerations on wider regulatory design in this area also need to be accompanied by further efforts to support research on algorithmic bias in education, including support for improvements in data collections (particularly on under-represented demographic groups in current research), additional funding for research and designing education-specific tools to conduct bias audits (Baker and Hawn, 2021[91]).

90. In addition to legal regulations on the use of AI and algorithm-based tools, further guidance must also be provided to educators to empower them to use these educational technologies responsibility and carefully and to critically question their implications on privacy and fairness requires. This requires formulating and disseminating guidelines for the application of AI and algorithm-based tools in schools. The European Commission's recent ethical guidelines on the use of AI and data in

teaching and learning mark a first effort in this area (European Commission, 2022[101]). However, more specific guidance on the use of particular AI and algorithm-based tools that reflect current usage in the context of specific education systems are likely needed.

Develop policies that support interoperability of technologies and portability of data

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

92. 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 IMS Europe (as a subgroup of IMS Global Learning Consortium) which cover learning platforms, learning data and analytics, integrated assessment tools and standards (IMS Global, n.d.[102]) 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.[103]).

93. 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 higher education institutions 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, in order 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.

94. 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 projects 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, standards bodies and educational technology 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.[104]).
- In **Germany**, the Federal Ministry of Education and Research is funding the development of a digital education platform or hub to integrate educational 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[105]).

- 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[106]).

Design quality assurance policies that permit (and support) the effective use of digital technologies in teaching

95. School systems need to develop a coherent quality assurance approach to digital education. More systematically incorporating a digital education dimension in quality assurance processes can support a more effective integration of digital technologies in teaching and learning, while also raising awareness about the increasing digital transformation of education systems. The expanding permeation of digital technologies in education systems require addressing the quality of digital education in a more continued and comprehensive way.

96. 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[107]). 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[5]) offer new avenues for monitoring and improving the use of digital technologies at the school level. 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[5]). 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[10]). 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[5]). In addition, and particularly in the aftermath of the COVID-19 pandemic, countries have also increased their efforts for ensuring the quality of digital learning resources. 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[108]). Such apps will be subjected to reviews and certification based on a range of criteria (educational-related, ease of use, data privacy, etc.).

97. Building a coherent quality assurance approach to digital education requires synergies between such a variety of quality assurance processes. While such evaluation mechanisms and tools, as well as the increasing use of digital technologies to support the management of schools and education systems, offer increased potential for ensuring digital education quality, European school education systems need to develop coherent quality assurance systems for digital education. Given the diversification and multiplication of evaluation and assessment tools and methods, education systems need to ensure synergies between them to ensure they provide a coherent and consistent approach (OECD, 2013[57]). Building a coherent quality assurance approach for digital education requires

articulations between the different components of evaluation and assessment frameworks, and developing a strategy or framework document that is tailored to digital education may be an effective start. In addition, capacity for quality assurance also needs to be supported at all levels, from teachers performing assessments of learning with digital technologies at the classroom level to school leader or education administrators who rely on data to monitor, understand and assess the outcomes of digital education. Capacity building is even more necessary when digital technologies are used as tools for assessment and evaluation, since many challenges remain in ensuring teachers' and school leaders' preparedness to effectively employ digital technologies and data as part of their work.

4 Infrastructure and Innovation for digital education

A high-quality digital infrastructure is the foundation of all digital education strategies and is a prerequisite for digitally enabled education systems. This chapter addresses the availability of digital infrastructure (e.g. availability of broadband in education institutions), its adequacy (e.g. in terms of connection speed, computing power) and the distribution of digital infrastructure (e.g. across education institutions, students, etc.) in education systems. It also examines how education systems can support innovation for digital education technologies through multi-dimensional and co-ordinated policy efforts.

State of play and 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

98. Network connectivity for schools 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 the speed and capacity requirements vary across tools, stable high-speed broadband connectivity with low latency facilitates real-time interactions related to education requiring the transmission of audio-visual data, such as synchronous (i.e. in real time) and asynchronous (i.e. self-paced) virtual interaction, including lectures, meetings and tutoring. Indeed, with the exponential explosion of data and audio-visual content, only a stable, high-speed connection is a useful one (>100Mbps to Gigabit). In turn, wireless broadband connectivity ensures full connectivity in large physical learning spaces such as university campuses.

99. The pandemic accentuated the trend to require 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 both fully online and hybrid modes of learning. Adequate connectivity at home matters particularly for lifelong learning, since it is often done online (in whole or part), and is especially dependent upon high speed Internet access and adequate home technologies. Network connectivity is not only necessary for performing digital learning activities; it can also support better learning outcomes (Sanchis-Guarner, Montalbán and Weinhardt, 2021[109]) and the transition to higher education (Dettling, Goodman and Smith, 2018[110]).

100. According to the 2021 European Union's Digital Economy and Society Index (DESI), in 2020: 77% of households had broadband; 87% had fast broadband (Next Generation Access or NGA) network coverage (but only 34% had access to fast - at least 100 Mbps - fixed broadband); 71% had mobile broadband; 99.7% had 4G coverage, 51% had 5G readiness and 14% had 5G coverage; while 59% had Fixed Very High Capacity Network (VHCN) coverage (European Commission, 2021[111]). 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.

101. In terms of network technology trends, 2021 data for 38 OECD member countries shows different technology mixes coupled with a strong move towards fibre, which now comprises 32% of fixed broadband subscriptions (20 percentage points more than a decade age ago (OECD, 2022[112]). 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 (up from 30% in 2020) (5G Observatory, 2022[113]). The new sixth generation mobile communication standard 6G is under development but at an early stage, with optimistic forecast projecting early deployment in 2028 and 2029 (ABI research, 2021[114]) (Saad, Bennis and Chen, 2020[115]).

102. Despite this progress in coverage and take-up, substantial disparities persist in access to and quality of Internet connection in rural versus urban areas. The rural-urban gap in households with fixed broadband subscriptions across EU countries was 12 percentage points (69% versus 81%) in 2021, with 10% of households not covered by any fixed network (European Commission, 2021[111]). Portugal,

Greece, and France have the largest rural-urban gaps in mobile or fixed broadband uptake across EU countries (OECD, 2022[116]). In 2019, only 59% of rural households in Europe were located in regions with access to at least 30 Mbps speed fixed broadband compared to 86% of households in all areas. Besides coverage, data from regulators in 26 OECD countries indicates a persistent rural-urban divide in Internet connection speeds: 1 in 3 households in rural areas do not have access to high-speed broadband on average and only 7 out of 26 OECD countries ensure access to a high-speed connection to more than 80% of households in rural regions (OECD, 2020[117]).

103. Connectivity at home has been critical in enabling students to remain connected to their teachers and peers, and continue learning outside of the school premises 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 (PISA, 2018). In EU countries, less than 1% of surveyed EU 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[6] benefited from an Internet connection at home than their peers in socio-economically advantaged schools in Bulgaria (6% gap), 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%).

Education institutions help narrow connectivity gaps, but high-speed Internet connection is not yet the norm in all communities and schools

104. Schools help narrow connectivity gaps in countries where socio-economic background or geography shape Internet access at home. Access to the Internet in schools was almost universal in 2018 in OECD and EU member countries. 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). Access to the Internet was already widespread in 2012 in EU countries with available data in both the PISA 2012 and PISA 2018 waves[7]. Socio-economically advantaged schools tend to have larger shares of computers connected to the Internet in Colombia (43% gap), Costa Rica (17.1% gap), Iceland (5.6% gap), Lithuania (1.7% gap), Luxembourg (5.1%), Mexico (41.8% gap) and Türkiye (16%). In contrast, the rest of OECD countries displayed no statistically significant gap in students' access to Internet-connected school computers for educational purposes by school socio-economic profile.

105. But access to an Internet connection at school does not necessarily imply its quality. If the Internet connection is slow, its mere availability is likely to be insufficient to support student learning. Many students in OECD countries continue to 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 reports that the school's Internet bandwidth or speed is insufficient (Figure 4.1.). Among European countries with available data, the share of schools benefitting from fibre optic cable connection has been on the rise, but only around 32% of students in primary schools, 40% of lower-secondary schools and 51% of upper-secondary schools had Internet access through fibre optic in 2017-2018 (European Commission,

[6] 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, 2019[325]).

[7] All EU countries with the exception of Malta. In PISA (2015), all school computers were connected to the Internet according to principals' reports in Malta.

2019[82]). The remainder of schools were mostly connected through ADSL, followed by cable connections, and only a minority of schools had satellite connections.

106. Education systems' capacity to support better learning using digital devices may be hindered if the quality of Internet connection is insufficient. Indeed, at the system level, across all OECD countries and economies, quality Internet access in schools is positively correlated with student performance and equity in reading[8], even after accounting for GDP per capita (OECD, 2020[118]). More generally, countries and economies with fewer material resources shortages, and in particular educational materials (e.g. ICT equipment, textbooks)[9] 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.

107. In European countries with available data, cross-country inequalities in students' access to fibre optic in schools remained particularly large before the pandemic (European Commission, 2019[82]). More than 80% of students in primary, lower-secondary and upper-secondary schools in Denmark were in schools with fibre optic. In contrast, in Germany, 19% of primary level students, 23% of lower-secondary students and 34% of upper-secondary students benefitted from fibre optic in their school. 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 4.1.).

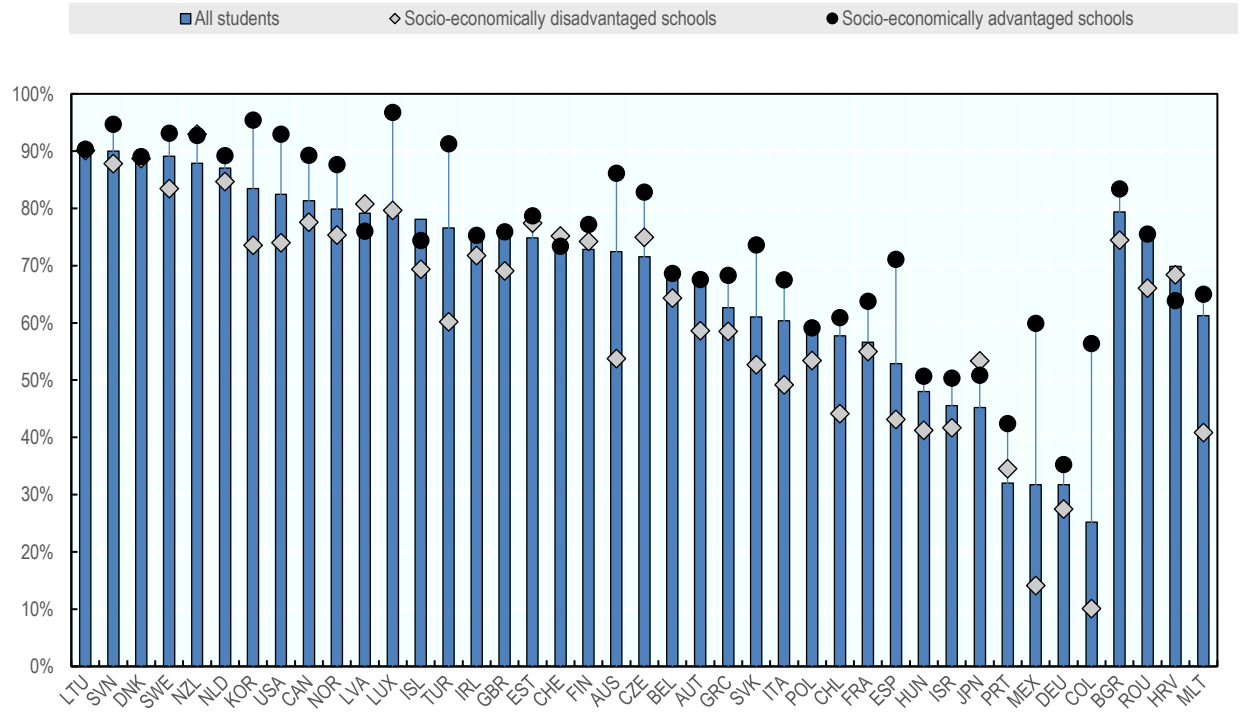
108. In addition, inequalities in access to a fast Internet connection persist also within countries. Students attending schools in rural areas are, on average, less likely to benefit from high-speed Internet and to connect to the Internet through fibre optic (European Commission, 2019[82]). Analyses 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, 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 Slovakia, 28% in Spain and 31% in Türkiye. 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 (PISA, 2018).

[8] 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[75]).

[9] Rather than physical infrastructure (e.g. building, grounds).

Figure 4.1. Sufficient Internet bandwidth or speed in schools, by school type

Percentage of students whose principals report that the school's Internet bandwidth or speed is sufficient, by school type



Source: Author's calculations based are based on data from OECD (2018[35]), PISA Database 2018, https://www.oecd.org/pisa/data/2018database/

OECD countries have not yet managed to articulate equity and quality in learners' access to digital education equipment

While access to computers in schools is almost universal in OECD countries, highly-digitally equipped and connected schools are not widespread

109. The share of highly-digitally equipped and connected schools varies extensively across OECD countries. 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[82]). In addition, on average across EU countries, the share of digitally equipped and connected schools is higher at higher education levels.

110. While highly-digitally equipped and connected schools were not yet widespread on average across the EU before the pandemic, access to computers for educational purposes was extensive in EU countries. OECD countries displayed a similar situation. On average across schools in OECD countries in 2018, there were 0.8 computers available for educational purposes for every 15-year-old student, and the computer-student ratio had largely increased since 2009 (OECD, 2020[118]). While in recent years the share of portable computers has been on the rise, not all students benefit from access

to such devices: on average across OECD countries, only 40% of computers were portable (e.g. laptop, tablet). 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 Australia (74%) and the United States (79%) (OECD, 2020[118]). Evidence from EU countries showed that most EU most students tended to access school desktop computers in school laboratories, which may limit the potential of digital technology use for learning if such computers are accessed on few occasions or only serve for IT classes. In contrast, only one third of lower-secondary students in the EU had access to desktop computers within the classroom (European Commission, 2019[82]).

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

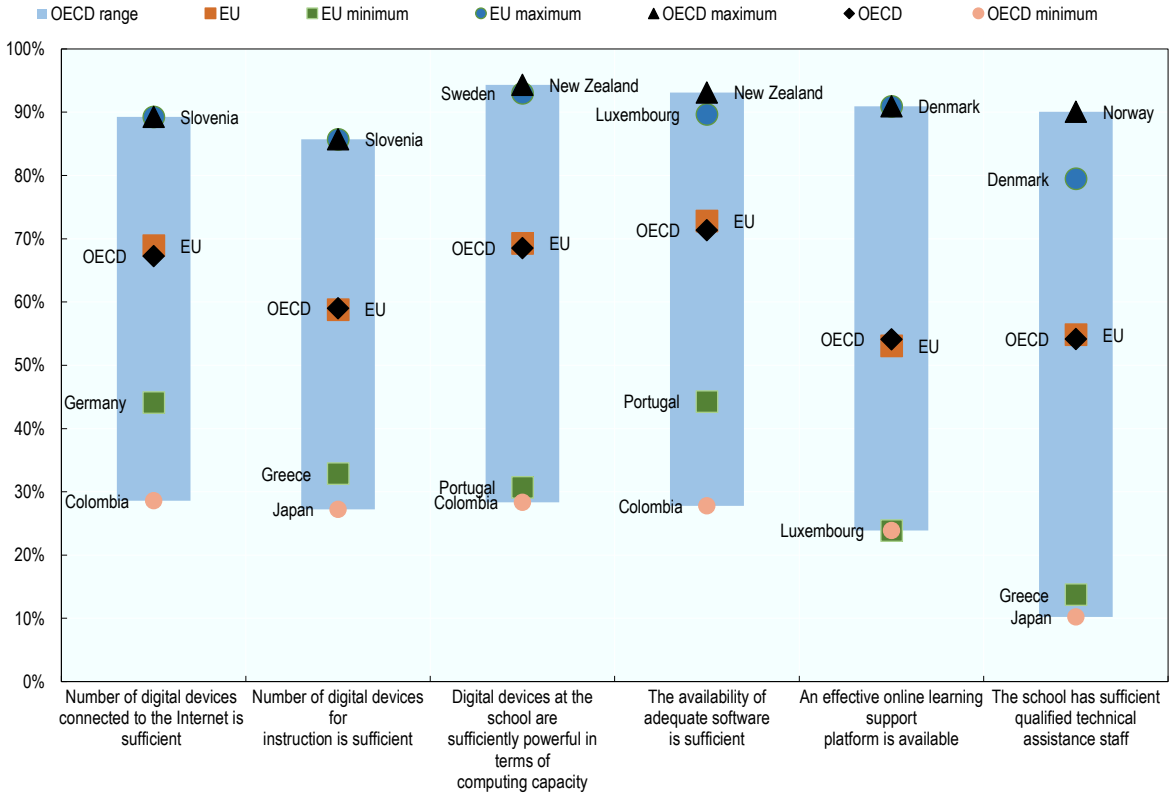
111. The mere availability of digital equipment is unlikely to be sufficient to support student learning if computers are old or educational software inadequate.

112. In addition, data from PISA (2018) provide evidence on the perceived adequacy of specific digital technologies available for learning and teaching in schools (Figure 4.2). Before the pandemic, there were large inequalities between OECD countries in their capacity to ensure student access to quality digital equipment in schools, whether in terms of providing sufficiently powerful digital devices, adequate software for instruction or access to an effective online learning platform. 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. This raises questions about the adequate distribution of computers within the school premises and availability of computers for regular instruction. Similar questions emerge also with respect to the quality of digital equipment available in schools. In European countries, 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[82]).

113. These figures also mask wide within-country inequalities. On average across the EU, perceptions of shortages or inadequate digital technologies are more recurrent among students from disadvantaged schools. For instance, the gap between students from disadvantaged schools and those from advantaged schools in accessing powerful digital devices at school is 29% in Colombia, 17% in Hungary, 36% in Mexico and 21% in Spain (PISA, 2018). TALIS data depicts 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[51]). Among EU countries with available data in TALIS (2018), only in Sweden does the availability of quality digital technology compensate for a challenging school environment.

Figure 4.2. Adequacy of digital technologies and availability of qualified technical assistance staff 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: Author's calculations based are based on data from OECD (2018[35]), PISA Database 2018, https://www.oecd.org/pisa/data/2018database/

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

114. 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. 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.

Divides also persist in students' access to educational software and Virtual Learning Environments

115. Yet, digital devices *per se* are only one facet, the first step to accessing an ever-increasing number of digital tools and services. Digital education platforms, educational 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 Virtual Learning Environment (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[82]). However, 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.

116. Before the pandemic, the share of students with access to educational software at home had stagnated across PISA countries with available data. In 2018, 58% of 15-year-olds in OECD countries had access to educational software at home, with students from socio-economically advantaged schools displaying substantially higher levels of access (PISA, 2018). 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[119]). However, as in the pre-pandemic period, socio-economically advantaged students who could afford purchasing such software are likely to have had greater access to such technologies except where government schemes supported students' access.

Adoption of advanced technologies has not become mainstream in education systems

117. Beyond standard or traditional digital equipment (e.g. digital devices), education systems can increasingly have access to a range of new and more advanced digital tools and products developed by educational technology companies (e.g. Augmented Reality (AR)/Virtual Reality (VR), Artificial Intelligence (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[120]). Before the pandemic, many digital education strategies in OECD countries continued to focus on traditional types of digital technologies rather than more advanced ones (van der Vlies, 2020[2]). As a result of the pandemic, a number of countries have increased their efforts for a more widespread introduction and use of advanced technologies such as AI-enabled tools or products in their school education systems. Korea and the United Kingdom are examples of countries who were both more advanced in the digitalisation of their education systems prior to the pandemic and who have also taken steps towards integration of AI in their education systems. Korea has been progressively introducing AI in education since 2018, expanding software education in primary and middle schools, opening AI pilot schools and designating high schools to develop AI-based models for education (OECD, 2021[73]).

118. Adoption of advanced technologies can however further widen inequalities between students of different backgrounds if these are more likely to be accessed by socio-economically advantaged schools 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[121]).

119. Cloud services including Cloud storage, Infrastructure as a Service, (IaaS) and Software as a Service (SaaS) have not been rapidly adapted in education. Suppliers of core software have moved to SaaS 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 toward 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.

120. 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[122]). 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.

While countries need to better measure investments in digital education technologies, existing evidence suggests digital innovation for education can be further enhanced

Expenditure on digital technologies in education represents a limited share of global education expenditure, but data remain scarce

121. While investment in schools' digital infrastructure has been at the core of digital strategies in most OECD countries, there is little systematic information on public expenditure on digital technologies in education institutions. A 2019 survey of European countries revealed the difficulty of identifying the actual governmental funds invested in digital infrastructure for school education (European Commission/EACEA/Eurydice, 2019[5]) (European Commission/EACEA/Eurydice, 2019[5]).

122. Across OECD and EU countries, more than 90% of public and private spending on educational institutions is devoted to current expenditure (OECD, 2021[123]). Compensation of teaching and non-teaching staff comprises the largest share of current expenditure in primary and secondary education on average across OECD and EU countries with available data: across OECD countries, 78% of current expenditure on primary, secondary and post-secondary non-tertiary education was devoted to teaching and non-teaching staff in 2019 (OECD, 2022[124]).

123. Estimates from the private sector 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[119]; HolonIQ, 2021[125]). Other estimates from market research companies provide an indication of the amounts spent by education institutions on digital technologies in some countries. 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[126]).

Educational technology venture capital funding has surged since the pandemic, but displays large cross-country variations

124. 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, and idea incubators (e.g. EdTech competitions) (Escueta and Holloway, 2019[127]). However, systematic data on the amounts invested in educational technology by most investor types are often lacking, with most existing evidence focusing on venture capital investments in educational technology (hardware, software and technology-enabled services). Governments can also intervene in venture capital markets by injecting public resources in venture capital markets. Disaggregated data on government-sponsored venture capital in educational technology is however not available.

125. Yet, available data on venture capital investments shows 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 educational technology venture capital levels (HolonIQ, 2022[128]). 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 educational 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[119]).

126. At the same time, educational technology venture capital funding in European countries (14% of global educational technology funding in 2021) remains lower than funding in other countries such India (18%) or the United States (40%) (IDB and HolonIQ, 2021[129]). Overall, the size of the educational 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[128]).

Investment in digital innovation (for education, and more broadly) is likely insufficient

127. These figures prompt questions about the sufficiency of investment (on aggregate – relative to other sectors, and in some OECD countries, including EU countries – relative to other countries) and involvement of private actors in the development of tools, products and services required by the challenges faced by education and training systems, particularly in emergency contexts (Vincent-Lancrin, 2020[130]). A range of factors are likely to hold back investment and innovation in this sector, including regulatory frameworks in education systems, a fragmented market demand for educational 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[131]).

128. 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 educational technology[10] were founded during the pandemic[11] (HolonIQ, 2022[132]). Research evidence shows that venture capital tends to direct its investment focus towards less innovative start-ups during economic downturns (Howell et al., 2020[133]). 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 educational technology firms in order to support their rapid scale-up (Dee, 2020[134]).

[10] (HolonIQ, 2022[132]) 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.

[11] These figures exclude the Baltic countries for which a separate share is computed and represents 12%.

Key policy responses and promising approaches

Further invest in providing reliable connectivity for equitable digital learning opportunities

129. 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 provided by markets including:

- coordinating, 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[135]) (OECD, 2021[136]).

130. In addition to policies targeting access to internet connection 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[137]). 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.
- 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[138]). The programme rests on two approaches. The Hub model approach that 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[139]). 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.

131. Other policy approaches and programmes increasingly focus on innovative uses of digital technologies to bring connectivity to learners in areas without broadband and/or limited cell service. Indeed, while a range of 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[140]). In this context, prescribing specific technology solutions for bridging connectivity gaps in these areas may be less effective than maintaining an open

approach to innovations and support technologies with growth potential in areas still reliant on legacy networks (OECD, 2021[140]). A range of programmes have thus 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[141]).
- 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[142]).
- 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 busses allow students to access the Internet during transit, once out of service the busses are also parked in underserved communities to provide broadband coverage.

132. Efforts have thus 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[120]). Other strategies (e.g. in Belgium, Spain, France or Latvia) included agreements with Global System for Mobile Communications (GSM) operators/Internet firms to remove Internet access barriers.

133. To help keep track of inequality in access across students, policies can mandate or cooperate 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 cooperation with telecommunication companies, schools and community trusts to co-create solutions for students lacking Internet access (Ministry of Education, 2021[143]).

134. The large capacity already installed to satisfy the links between higher education and research institutions to the NREN backbone network[12] 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[144]). 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[122]).

[12] Backbone networks interconnects networks by providing a path for the exchange of information between different LANs or subnetworks.

Ensure sufficient and inclusive access to quality digital equipment and tools

Bridge digital equipment gaps in education institutions

135. While the pandemic has shifted the focus of debates on digital equipment to private households, education systems have largely returned to in-person teaching requiring renewed focus to digital equipment on school premises. In this context, the disparities in digital equipment between advantaged and disadvantaged schools highlighted in previous sections become once again critical. This calls for further investments to bridge gaps in digital infrastructure between schools but also to ensure the adequacy and quality of digital equipment overall. In fact, several countries have passed significant investments in schools' digital infrastructure over the recent years with a focus to support the digital facilities of disadvantaged schools. 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 DEIS (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[145]; Department of Education Ireland, 2022[146]).

136. With the upward trend of ownership and use of end-user hardware in the home (OECD, 2022[147]), some education institutions have turned to a Bring Your Own Device (BYOD) strategy to bridge equipment gaps. BYOD 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 between family members, or inadequate device quality (e.g. battery life or incompatibility with specialist software) might render these devices unfit for the 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[2]). Combining BYOD approaches with central provision of digital devices might be a promising step to address these concerns whilst leveraging existing district-owned tools:

- For instance, **New Zealand** has traditionally relied strongly on BYOD policies at schools, with 55% of schools already having implemented BYOD 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[148]).
- Further, 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[149]). The district also provided devices (for school use only) to those students who lacked a device.

137. One-to-one earning initiatives which equip students with portable devices have been pursued to remove barriers to digital education. Such one-to-one laptop or tablet programmes have been designed to enable all students to have access to digital devices in schools and take them home. In **Uruguay**, the first stage of the Plan Ceibal provided laptops to students and teachers in public schools, together with free Internet connection (OECD, 2020[150]).

138. 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[75]). 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[151]). Better documenting teachers' access to quality digital equipment in schools and at home and supporting teachers who lack access to the necessary digital tools is a key precondition for successful digital education.

139. Another relevant area for policy intervention relates to the development and maintenance of databases of available education technology tools/services and their use. Yet, collecting data on the diversity of digital tools and particularly software now available for student learning has proven challenging, in light of fast technological advances in the field and many measurement gap areas remain. While some data collections have integrated more novel tools, data on penetration of advanced technologies (e.g. AI-based educational tools) across schools and education systems is lacking. Going beyond the availability of hardware and focusing on better understanding the type of digital tools or technology-enabled services that students, teachers and education administrators rely upon would enable better assessing digital divides and designing more effective policies for bridging them. In addition, 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. Better informing 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.

140. During the pandemic, partnerships between education institutions as well as between private companies and the public sphere have proved essential in mobilising resources and finding technical solutions to deliver distance learning (Vincent-Lancrin, Cobo Romaní and Reimers, 2022[120]). Developing and supporting collaborative efforts beyond the pandemic can be a further step in bridging inequalities in the access to digital equipment. For instance, partnerships between schools can revolve around pooling resources for infrastructure in cases where single education institutions do not have the appropriate digital infrastructure individually. 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 ICT experts in schools or more general. For instance, **Estonia** has developed long-standing cooperation 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[152]). However, 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.

Promote access to digital devices at home

141. 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.

142. Even before the pandemic, many national policies sought to provide students with portable devices for learning (Conrads et al., 2017[153]). 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[154]; Escueta et al., 2017[155]). 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[156]).

143. 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[120]). For instance, in **Korea**, the Ministry of Education cooperated 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[151]).

Take a forward-looking and evidence-based approach to investments in digital infrastructure

144. 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[147]). Ensuring sufficient access to digital equipment and tools thus requires anticipating investment needs before shortages and inadequacies arise. Global expenditure on advanced technology (e.g. AI) in education is expected to surge in the following years and such technologies may increasingly permeate education systems. In addition, existing digital equipment and tools require upgrades to ensure an effective use. If new software or tools enter education institutions, with higher connectivity or computing capacity requirements, investments to upgrade or adapt such infrastructure need to be anticipated. In this respect, governments and education institutions need a forward-looking approach for investing in digital technologies: investments in the development of digital infrastructure need to address not only existing needs but also anticipate future needs. Performing horizon scanning and taking stock of technological developments is key to better inform policies in the field and ensure that digital infrastructure in education systems can keep the pace with advances in educational technology.

145. In fact, recent experimental research demonstrates that education software bears higher fixed and maintenance costs than traditional 'pen and paper' tools, while the marginal costs are at a similar level (Ma et al., 2020[157]). In a context in which the technology-based component of the learning intervention (over and above traditional pencil-and-paper learning) only result in moderate to null effects on academic achievement, the cost differential between technology and traditional tools thus triggers questions about the efficiency of investments in digital technologies for education. Further analyses, including cost-benefit, would allow for better-informed investment in and allocation of digital technologies in education systems.

146. Current 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 and distributing computers, and also resulted in higher levels of computer use and higher levels of computer skills (Escueta et al., 2017[155]). 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 ICT resources in schools (e.g. computer hardware or Internet access) is insufficient to enhance student *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[154]; Escueta et al., 2017[155]). The more positive research evidence on the impact of education software use on student

outcomes suggests that policies targeting an expansion in access to digital equipment and connectivity should also integrate specific learning tools or interventions, and address the wider learning ecosystem susceptible of shaping students' use of these technologies (e.g. guidelines or support for parents, building teachers' digital pedagogy skills).

147. The above evidence indicates that investments in digital infrastructure are rewarding only insofar, as they are accompanied by sufficient capacity building components. This pattern also holds for infrastructure investments to close the digital divide: Evidence from the COVID-19 pandemic has shown that once 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[158]). Ensuring a successful implementation of policies addressing equipment gaps thus also requires supporting students, parents, teachers, schools leaders and education institutions in the use and management of such devices. 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 6 on building capacity for digital education analyses these aspects in more depth.

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

148. 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 and other countries (e.g. the United States). However, boosting digital innovation in education usually exceeds the realm of education policy. Rather, a broader policy spectrum including 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 of education technology 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 research and development for digital innovation, iv) incentivising innovation through tax-based credits and v) policy experimentation (OECD, 2020[159]).

149. Nonetheless, education authorities are responsible for creating the background conditions conducive to innovation in education technology. For instance, ensuring connectivity in education institutions and for all learners, providing the appropriate equipment within the education sector and the skills to make the most of it are key preconditions to support demand for digital education technologies products, and thereby create incentives for investment and innovation in this area. Further, several countries have launched specific support measures for the education technology sector. These include support to access finance and business investment, setting up innovation funds and provision of grants for digital educational technologies development and innovation, support for educational technology incubators or accelerators, and visa classes to attract technology specialists from abroad. In particular, government funding might 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[160]).

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

- The Helsinki Education Hub in **Finland** provides support for EdTech entrepreneurship and new business, through 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[161]). 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 cooperation with a range of partners including universities, private sector companies focused on digital technologies, the Finnish EdTech industry association, etc. (NewCo Helsinki, 2021[162]).

- 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 (NESTA) 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[163]). The grants were targeted at organisations working on technologies related to formative assessment, parental engagement, essay marking and timetabling in order 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[163]).

151. Efforts can also focus on encouraging private investments in educational technology development. Designing incentives for the private sector to invest in innovation for education requires understanding the structure and dynamism of the educational technology market (World Bank, 2020[164]). While venture capital investments in educational technologies have grown substantially in the last decade, the pandemic and previous economic downturns have shown that the most innovative educational technologies do not always attract the largest investments (Dee, 2020[134]). Strategies to maximise returns on investment, based on scaling up rapidly by attracting a large user base, may lead firms and investments to focus on existing or familiar technologies rather than on more innovative and hence, potentially riskier, technologies (Reich, 2020[165]). Partnerships between diverse stakeholders can incentivise private investments in riskier technologies. 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[166]).

152. Governments should also aim for better monitoring of investment and developments in the educational technology industry. Currently, most evidence on the scale of the global digital educational 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 educational technology industry and on the market for educational technology specifically, including the presence of potential market failures (Vincent-Lancrin, Cobo Romaní and Reimers, 2022[120]). Such an infrastructure would in turn allow better informing and targeting innovation-related policies for digital education technologies. More information on the composition of investment (public and private) would equally enable better understanding how much additional investment is needed and how it should be directed to help EU countries catch up in terms of digital innovation in education. Chapter 7 analyses more in depth the design of a monitoring and evaluation infrastructure for digital education.

153. Finally, governments need to encourage better collaboration between education and training institutions and developers of educational technology to ensure that new tools and equipment actually match the needs of and contexts in which education institutions, educators and learners evolve. 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. The second background document of this project will analyse these aspects more in depth as they relate to policies needed to support an effective use of digital technologies for teaching and learning.

5 Resourcing the deployment of digital education

This chapter examines how countries can effectively resource the deployment of digital education. It addresses how funding frameworks can be designed to back up policy objectives with the necessary financial resources. The chapter also covers how human resources frameworks (incl. career structures, progression criteria and working time arrangements) can be adapted to support an effective use of digital technologies by educators and educational institutions.

State of play and challenges

Funding of schools (and students) for digital education

154. Investing in the digital transformation of schools and universities is a priority issue for many OECD education systems. Nevertheless, comparative data on digital education expenditure and its efficiency remains limited. Institutional funding models also need to adapt to new forms of digital education provision (e.g. the participation in online courses) and respond to the challenges associated with a highly fragmented market for digital education technology. The following sections describe what we know about investments in digital education technologies from an international perspective and outlines some of the key challenges that education systems face in adapting their institutional funding mechanisms for the digital age.

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

155. 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[13] (more than 90% on average across OECD and EU countries with available data), with the remainder being devoted to capital expenditure[14] (OECD, 2021[123]).

156. In school education, across the OECD in 2018, the largest share 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, pp. 311, Table C6.2[123]).[15]

157. Evidence about expenditure devoted specifically to digital education, is much more scarce. An OECD Digital Economy Policy Questionnaire administered in 2016 reveals that among the 38 OECD and partner countries surveyed, around 75% of countries reported allocating funds to set 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 goods and services in education were related to financial support for ICT equipment or Internet connections for public schools: around 50% of surveyed countries reported implementing each of these policy types. Policies for buying or developing digital learning materials (e.g. e-textbooks) were less common (reported by 25% of surveyed countries) (OECD, 2017[3]).

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[13] 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[123]).

[14] 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[123]).

[15] 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.

158. However, despite such policy surveys evidence, no consolidated internationally comparative data exist to provide an overview of either the sums dedicated to digital learning by education institutions at various levels of education, nor government expenditure to support digital learning in education institutions. Part of the difficulty in collecting these data is that institutional accounting and financial reporting systems are not designed to identify and bundle the different types of expenditure that support digital learning, which may include budgets for central information technology (IT) services, investment in infrastructure and equipment, external digital service providers, dedicated support staff in school and HEIs' departments and faculties, and time spent by staff on developing and delivering digital content and programmes of learning.

159. As for the levels of expenditure, there is also limited evidence on the funding needs of schools on digital education, although TALIS data suggests 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, pp. 207, Table I.3.63[32]). 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). At the country level, 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, pp. 207, Table I.3.66[32]).

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

160. 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[123]). Education systems across the OECD display a complex distribution of responsibilities for allocating funding across education sectors (OECD, 2017[167]). 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[167]). Sub-central authorities increasingly engage in raising resources, allocating and managing school funding. While reliance on own 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[168]).

161. When sub-central authorities are in charge of funding school education largely from their revenues, inequalities between authorities will translate in inequalities in the quality of education and students' opportunities. Such inequalities are exacerbated by the mutually reinforcing effects of digital technologies on the one hand and education and skills on the other hand. The benefits of digital technologies have been shared unequally within countries, with cities and areas with a technology-intensive local economy attracting highly educated workers and new technology-related jobs being created in areas with a highly skilled population (OECD, 2019[7]). In addition, schools are also increasingly responsible over budgetary matters, which might result in higher inequities between schools if some schools lack the administrative capacity and preparation to deal with budgetary responsibilities. However, little systematically-collected and cross-country 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.

Effective digital education requires a combination of current and capital expenditure

162. The deployment of digital education technology requires both current and capital expenditure. While the establishment of broadband connectivity and the acquisition of digital equipment generate capital expenditure, other costs are likely to be recurring parts of education institutions' current expenditure, for example those for the continuing education of education staff, the provision of ICT 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 current and capital expenditures and strike the right balance between short-term and long-term investments.

163. On average across OECD countries, 91% of the public and private funding for primary to tertiary education is dedicated to current expenditure and 9% to capital expenditure, although there is significant variation in their relative share across countries. There is also variation across levels of education, with a lower share of capital expenditure observed at the non-tertiary levels (9% in primary and 8% in secondary education) than at the tertiary level (11%) on average (OECD, 2021, pp. 310, Table C6.1[123]).

164. Finding the appropriate balance between current and capital spending on digital education resources should reflect countries' digital education targets and their current state of digital education development, while balancing other potentially conflicting priorities. Striking this balance remains a challenge for many countries and failing to do so can lead to inefficiencies. When education institutions face trade-offs between current and capital expenditure, for example, there is a risk for long-term investments to 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[19]).

165. Many school systems rely on separate mechanisms to allocate capital and current funding and responsibilities for the two may be divided between different authorities. At the same time, the classification of some types of expenditure (e.g. for maintenance activities) as current or capital expenses, can be ambiguous (OECD, 2018[19]). The relationship between recurring costs and one-off investments is particularly relevant in the case of digital technologies, many of which require continuous upgrading, maintenance and support.

Funding allocation mechanisms for digital education can raise issues of access and equity, sustainability and administrative efficiency

166. 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[167]; OECD, 2018[19]).[16] Among OECD countries covered by the School Resources Review, the most common allocation mechanisms for current expenditure include earmarked grants, that require recipients to use the funding for specific items of current expenditure, and block grants, which recipients can use at their own discretion for allocations within current expenditure. In the case of capital expenditure, the main

[16] For current expenditure, governments can allocate 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, 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.

allocation mechanisms include infrastructure investment programmes and ad hoc administration of grants.

167. These allocation mechanisms can provide insights on how funding for digital education can be distributed within the system, although consolidated data on the funding of digital education and its allocation is currently lacking. Alongside the main funding allocation mechanisms, governments also rely on targeted programmes or grants for specific schools, students or areas, whether for current or capital expenditure. During the COVID-19 pandemic, 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.

168. Whether funding for digital equipment, the training of teachers for digital education and other digital education-related investments are channelled through the main allocation mechanisms or rather through targeted programmes matters for ensuring that funding reaches schools and students most in need. While targeted programmes may be more responsive to specific needs and emergency situations, they are also less sustainable, can be run in an un-coordinated way and overlap, and increase administrative costs for schools (OECD, 2017[167]; OECD, 2021[168]).

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

169. Investments in digital infrastructure take place in an ecosystem comprised of education administrations, education institutions, educators, learners, parents and other stakeholders interacting with one another. This ecosystem is highly fragmented and includes a multiplicity of potential buyers of educational technologies, which makes it difficult for educational technologies providers – especially smaller ones – to scale up and grow.

170. 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[169]) (OECD, 2021[136]). And 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, pp. 334, Table II.4.1[170]). 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. Czech Republic and Estonia) display a more intermediate level of budgetary autonomy.

171. Yet, investment decisions do not only require budgetary autonomy, but also IT expertise to make the most strategic decisions. Indeed, investing in digital infrastructure requires balancing the suitability of the infrastructure against digital readiness and current and future needs of education systems. Purchasing digital equipment usually does not represent a one-time investment as it is subject to continuous upgrading, maintenance and support. 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 Heigher Education Institutions (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.

172. Procurement strategies help institutions find a balance that works according to their needs and capacity. The extent to which institutions are able to make outsourcing 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 (or "box shifting") as well as IT expertise as part of the procurement ("service relationships"). Ear-marked 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. Moreover, 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. This is the case of Cloud services, for which paying up front for multiple years has been the only way to work around rigid procurement frameworks.

Human resource policies for digital education

173. The digital transformation of education systems is profoundly changing the way educators work. The policies that shape teachers' and educators' working conditions, their use of time and engagement in continuing professional learning also 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. The following sections describe what we know 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.

School systems provide few incentives for educators to use digital education technologies

174. Technology-based innovation in education extends beyond the use of technologies in classrooms. It can touch on system organisation, working practices and professional learning for teachers, school leaders and educational administrators to become innovators themselves. How to encourage and sustain innovation at all levels and among all actors of the system is thus largely dependent on adapting human resources policies within the system to support such innovation.

175. Well-designed career structures can support an effective deployment of education staff and make the most of their skills in education institutions (OECD, 2019[171]). In 2018, few OECD and EU countries had multi-stage vertical career structures that would have enabled teachers to be promoted based on a succession of formal positions with distinct task profiles and progressive responsibilities (OECD, 2019[171]). Such career pathways may encourage teachers to engage in a wider variety of roles related to digital education in their schools (e.g. as ICT coordinators, taking leadership positions focused on digital resources management in support of the school leader) and have their investment formally recognised.

176. Digital education strategies in OECD countries tend to focus on ICT infrastructure and digital learning environments, as well as the development of digital competence and equity-related issues (OECD, 2019[172]; OECD, 2020[173]). This raises the question of whether there are sufficient and appropriate mechanisms at different levels of education systems to incentivise an effective use of ICT resources. Evidence from European countries shows that across all levels of school education, the methods most commonly applied by schools to reward 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[82]). However, only one third of students attends schools that offer such rewards to teachers and one fifth of students in primary education (European Commission, 2019[82]). 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, pp. 267, Table V.B1.5.15[75]).

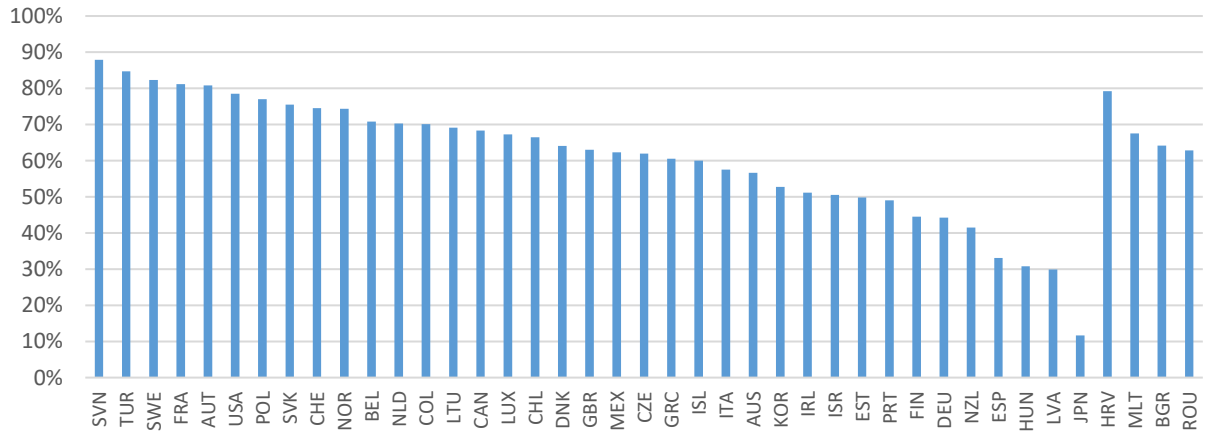
The use of digital technologies can help teachers to carry out routine tasks more efficiently but also adds new demands on their time

177. 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 tend 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[7]). 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.

178. On the one hand, the greater use of digital technologies (particularly during the COVID-19 pandemic) has increased the complexity and diversity of tasks teachers are expected to engage in (OECD, 2019[32]). Even before the pandemic, many teachers reported their workload to be a major source of stress (OECD, 2020[33]). 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 (Figure 5.1.). 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 (OECD, 2020, pp. 268, Table V.B1.5.15[75]).

Figure 5.1. 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[75]), *PISA 2018 Results (Volume V): Effective Policies, Successful Schools*, https://doi.org/10.1787/ca768d40-en, Table V.B1.5.15.

179. 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[32]). Evidence from a survey of over 2000 teachers in Canada, Singapore, the United Kingdom and the United States also suggests that teachers spend between 20% and 40% of their time on activities that could be automated.

According to a study, particularly lesson preparation, administration, evaluation and feedback hold significant potential for automation, which could help teachers to spend more of their time focussing on core instructional activities (McKinsey, 2020[174]). 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[175]).

Key policy responses and promising approaches

Adapt funding and revenue models to digital education

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

180. The development and introduction of new forms of digitally enhanced learning and – in relevant circumstances – new fully online programmes costs money. Alongside the cost of staff time for development and support, come requirements for additional digital infrastructure (such as recording and broadcasting spaces) and investment in staff training and capacity building. As noted above, there appear to have been few systematic attempts to quantify these costs at the level of school education and public higher education systems.

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

181. Funding allocation mechanisms need to account for the different resource needs schools face in the area of digital education. Targeted programmes have been widely used during the COVID-19 pandemic to support specific student categories or schools in accessing better digital equipment. However, as digital technologies will increasingly permeate education systems, including equity criteria to systematically allocate more funding for digital education to certain categories of schools or students, and revising funding mechanisms when needed to achieve a more equitable distribution of funding for digital education may be needed. Evidence from OECD countries shows that striking a balance between main allocation funding and targeted programmes supports equity in education systems more efficiently (OECD, 2021[168]). In this context, the underlying data used as a basis for funding allocations is crucial. The availability and quality of data, the design and complexity of indicators are important determinants of the accuracy and efficiency of funding allocation systems (OECD, 2017[169]). 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 efficiency of funding allocation systems. In addition, monitoring the effects of funding for digital education and evaluating their equity outcomes is needed to better target financial support and ensure that financial efforts translate into improved digital education opportunities for all.

Support institutions in budgeting and purchasing digital infrastructure

Support better institutional procurement strategies and budget practices

182. For education institutions, taking responsibility over the acquisition of digital education infrastructure implies having sufficient information, capacity and skills to navigate in a wealth of educational technologies products, services and tools, as well as understanding of procurement procedures to make effective choices.

183. Procurement strategies can be helpful in addressing issues of information asymmetries. Indeed, without proper information, institutions may end up acquiring technology that requires too much IT support or is too complex to use, leading to ICT infrastructure under-utilisation. 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 ICT 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[176]). This type of government support aligns with the broader 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[177]).

184. 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 include, for example, a Procurement Group that advises on ICT acquisition decisions, and a Digital Infrastructure Group that advises on technology and services that sit between networks and end-user applications (UCISA, 2022[178]).

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

185. Within the context of national and supranational procurement rules and directives, including the Directive 2014/24/EU on public procurement (EUR-Lex, 2014[179]), countries give education institutions different degrees of freedom in choosing suppliers for their digital infrastructure needs. In this context, if demand for educational technologies tends to be decentralised to educational agencies or schools, procurement practices and options are also likely to vary, albeit within the common objective to achieve scale economies and efficiency gains wherever possible, while adapting to the specificities of the system governance and level of budgetary autonomy.

186. At one extreme, in the most centralised systems, a centralised procurement approach, whereby a state agency buys ICT systems and equipment on behalf of all the institutions in the national education network is likely to be most effective. For instance, in **Hungary**, all public HEIs' procurement requests are considered, prioritised and acted on by a national agency (OECD, 2021[8]). In choosing full control over procurement, governments aim to: reduce the complexity and risks of procurement systems; improve efficiency by avoiding duplication; and ensure systems meet given standards and are interoperable. A centralised strategy makes sense when institutions have low internal capacity and resources to dedicate to a procurement strategy. For institutions that can build that capacity, centralised services can be perceived as inflexible, slow and unable to tackle requests for specialised items that are de-prioritised in the national agenda (OECD, 2021[8]).

187. In more autonomous systems, by contrast, governments allow education institutions to decide on their digital infrastructure investments, 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[180]). 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[181]).

- 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[2]).

188. Other countries, at the tertiary 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 ICT architecture to centralise, harmonise and standardise services related to security and access (UNIT, 2021[182]), but gives institutions freedom to choose services that can be tailored to their needs such as LMS and Virtual Learning Environments (VLEs) (OECD, 2021[8]). 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.

189. Comparative evidence on the procurement practices for educational technology is, however, currently lacking. Collecting such evidence would entail a better understanding of how different practices better support education systems in acquiring educational 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 difficulties 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

190. 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 cooperative association of school boards that supports purchasing of educational resources, including through the provision of framework agreements with providers leading to lower costs for schools (Nederland Digitaal, 2022[183]). 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[184]).
- In **Lithuania** and **Croatia**, consortia and NRENs provide centralised hosting services such as Zoom and Moodle on top of providing network connectivity (LieDM, 2022[185]) (CARNET, 2022[186]).
- 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[187]).[17]

[17] 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

Adapt human resources policies for an effective use of digital technologies in schools

Design career structures that recognise and reward teachers' and school leaders' engagement in digital education and their professional growth

191. Some OECD and non-OECD countries have successfully designed career pathways that offer vertical and horizontal opportunities for professional growth and can thereby provide more incentives for teachers' engagement in digital education. For instance, 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 a role of ICT coordinator, and thereby develop skills and devote themselves more in-depth to this specific area (OECD, 2019[171]). **Singapore** (a country that is also ahead in the 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.

192. The increasing use of digital technologies in teaching also translates into a need to reconsider methods and tools for recognising teachers' skills acquired while integrating digital technologies in their pedagogy and developing digital learning materials. Recognising skills acquired by teachers as they try to develop innovative teaching practices with digital technologies is critical to encourage teachers' autonomous engagement and efforts in such activities, and the continuity of such practices. Digitalisation 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[188]). 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. In the **United States**, a number of states have enabled teachers 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[188]; DeMonte, 2017[189]).

Review working time and staff arrangements for digital education in schools

193. 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[171]). However, teachers carry out a significant amount 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.

194. 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[32]; Boeskens and Nusche, 2021[190]). 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[32]; Boeskens and Nusche, 2021[190]), digital education will likely continue to transform the tasks performed by teachers and thereby, their need for support.

6 Building capacity for digital education

This chapter focuses on building sufficient capacity at all levels of the education system to successfully use digital education technologies to enhance student learning. It takes stock of the preparedness of actors across the system (institutions, educators and the broader learning ecosystem incl. students, parents and administrations) and presents policy levers that can support and strengthen capacity among actors at each of these levels.

State of play and challenges

195. In recent years, many OECD education systems have significantly expanded the digital education infrastructure in schools in an effort to reap the benefits of digital education. However, as infrastructure barriers have been reduced and technological possibilities for ICT-enhanced teaching have expanded, the digital competence of teachers, institutional leaders, administrators and their capacity to put these technological tools to use has emerged as a central challenge (Krumsvik, 2008[191]). The following sections describe what we know about education systems' capacity for digital education (considering educators, institutional leaders and the broader learning ecosystem) and the challenge they face to enhance it.

Educators are increasingly confident in using digital technologies, but many would benefit from further training

196. There is a growing consensus that governments need to move beyond investing in and widening access to digital resources in order to ensure their effective use in education. This requires strengthening capacity at all levels to ensure that educators have the necessary training and tailored support to use digital tools effectively to achieve greater personalisation in learning, improved student engagement, and greater inclusion through assistive technologies.

School teachers' preparedness for digital education varies greatly across countries and many report a need for further ICT training, despite progress in recent years

197. 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[192]) and many report a need for further training in the use of ICT for teaching.

198. 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 only 27% in Japan to 84% in Lithuania (OECD, 2020, pp. 266, Table V.B1.5.15[75]).[18] 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 own students' ICT skills (Fraillon et al., 2014[193]).

199. 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

[18] Among EU countries, the proportion was 66% on average and ranged from 49% in Ireland to 84% in Lithuania.

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, pp. 207, Table I.4.13[32]). 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, pp. 207, Table I.4.20[32]).[19]

200. 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 EC 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[150]; Minea-Pic, 2020[194]; European Commission, 2013[54]). Training is thus a critical factor in moving from the mere availability of ICT in schools to its actual use (Gil-Flores, Rodríguez-Santero and Torres-Gordillo, 2017[195]).

201. 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. 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, pp. 209, Table I.5.21[32]).[20]

202. As discussed in the analytical framework [EDU/EDPC/SR(2023)2], the effective use of ICT 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 ICT in the classroom may contribute to or exacerbate their difficulty in teaching students with SEN, which raises concerns for equity and inclusion (OECD, 2019, pp. 209, Table I.5.21[32]). 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 SEN teacher education programmes do not include mandatory modules on the use of digital technologies to support SEN students (Atanga et al., 2020[196]).

203. Although no international comparative data on the use of digital assistive technologies is available, TALIS 2018 data shows 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 special education needs. 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 special education needs is above 10% (OECD, 2022, pp. 103, Table 3.15[51]).[21]

[19] 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).

[20] 16% on average across the EU, ranging from 9% in Slovenia and the Flemish Community of Belgium to 26% in Croatia.

[21] On average across EU countries, the relationship between the use of ICT and the share of students with SEN is not statistically significant.

204. Building capacity for digital education is also an important concern for the VET sector. In light of rapidly digitalising work environments, VET teachers need 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[36]). To be able to use digital technologies effectively and follow technological innovations in the workplace, VET teachers need to have strong digital skills themselves.

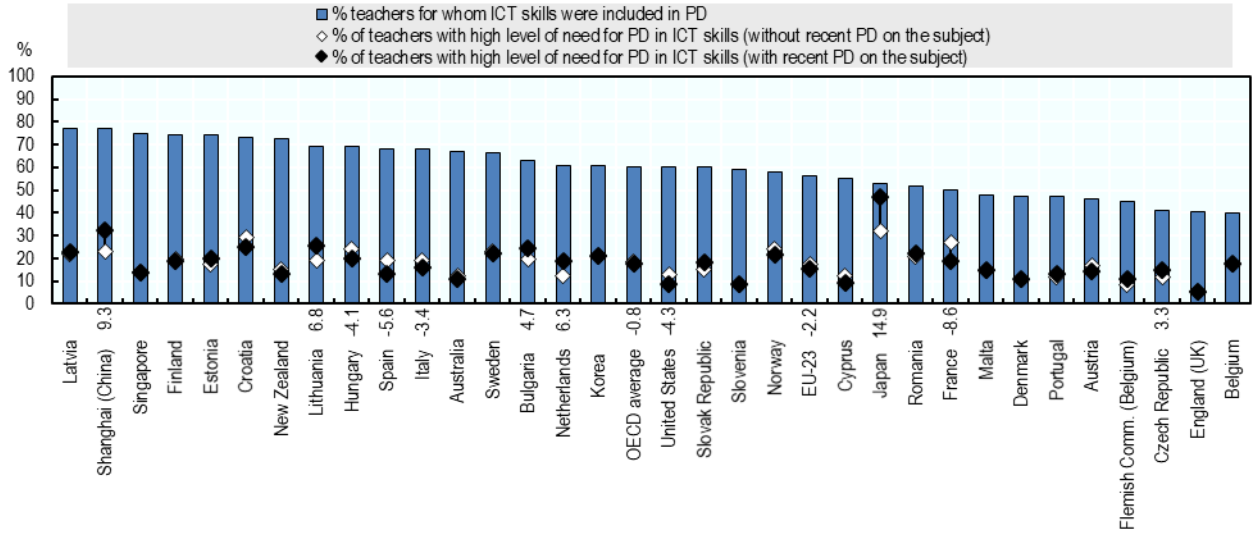
205. The use of digital technologies in VET education is already widespread. In the six OECD countries and regions with available data from the 2018 TALIS survey, [22] 74% of upper secondary VET teachers reported to work with digital technology with their students, compared to 66% of general education teachers (OECD, 2021, p. 131[36]). Data from the European Commission's SELFIE further suggests that VET teachers are slightly more likely than general education teachers to report using digital tools for teaching (OECD, 2021, p. 132[36]; Hippe, Pokropek and Costa, 2021[37]). However, a large proportion of VET teachers remain not sufficiently equipped with the skills required 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[36]).

206. In 2018, 60% of lower secondary teachers (general and VET) 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, at 18.4%, among those who had not received ICT training over the past 12 months. As can be seen in Figure 6.1. , 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 others (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[32]).

[22] 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[36]).

Figure 6.1. 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 shown next to the country/economy name.
Source: OECD (2019[32]), *TALIS 2018 Results (Volume I): Teachers and School Leaders as Lifelong Learners*, https://doi.org/10.1787/1d0bc92a-en, Table I.5.24.

Variation among schools' capacity to use digital technologies poses equity challenges

207. 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 take to promote students' learning.

208. Effective instructional 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[197]; OECD, 2022, p. 61[51]). 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[198]). 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[33]).

209. 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, pp. 205, Table I.2.42[32]). Likewise, teachers under age 30 were more likely to feel that their colleagues are not sufficiently open to change (OECD, 2019, pp. 205, Table

I.2.38[32]). 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[32]). 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 the 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, pp. 205, Table I.2.35[32]).

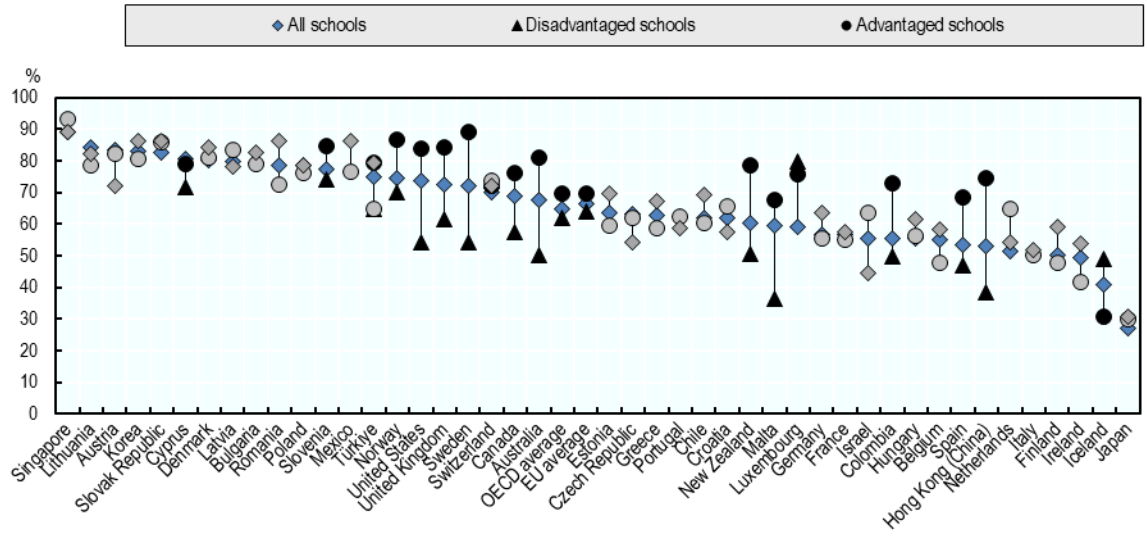
210. Principals seeking to lead their schools towards the effective integration of digital education technology have to contend with widely diverging levels of sources and existing capacity. In TALIS 2018, on average across OECD countries, 27% of school leaders reported that a shortage or inadequacy 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, pp. 205, Table I.3.63[33]).[23] Such a shortage of ICT resources in schools can limit teachers in their ability to enhance their teaching with the help of digital technology.

211. PISA 2018 data also suggests 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 6.2.).

[23] Among the EU countries with available data, the average stood at 27%, ranging from less than 10% in Slovenia and Malta to more than 40% in Romania and Portugal.

Figure 6.2. 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[75]), *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.

212. Similar deficits in schools' preparedness for the use of ICT can be observed in other domains, including the availability of technical support. 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, pp. 266, Table V.B1.5.16[75]; OECD, 2020[76]).

213. 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, pp. 266, Table V.B1.5.16[75]; OECD, 2020[76]). 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, pp. 28, Table 1.2[51]).

The wider learning ecosystem also needs support for successful digital education

214. 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[59]). 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[59]).

215. To make the most of digital technologies for learning, students must be equipped with a range of skills, not just digital competence. Having a good level of literacy, numeracy and problem-solving skills in technology-rich environments enables individuals to move from elementary Internet uses to more diversified and complex uses (OECD, 2019[7]). Students' cognitive (including digital) and socio-emotional skills are thus crucial determinants for their engagement in digital education and capacity to seize the benefits of digital technologies. Low-skilled students, like adults, are, for instance, more likely to use the Internet for recreational rather than instructional activities (van Deursen and van Dijk, 2014[199]; OECD, 2019[7]).

216. 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, average across the OECD and EU countries with available data in the OECD Survey of Adult Skills (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 inclusiveness 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]).

217. 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 navigation abilities in 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[44]).[24] Such navigation behaviours displayed strong correlations with students' reading performance and effective reading strategies.

218. In addition, parents 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[30]). Parents help their children maximise the benefits they can derive from the use of digital technologies, while minimising the risks associated with the latter. However, low-skilled parents are more likely to adopt restrictive mediation strategies by reducing exposure to online risks but also the likelihood that children benefit from the opportunities of digital technologies (Livingstone et al., 2017[200]). In contrast, high-skilled parents tend to rely on enabling approaches to Internet use that incorporate safety efforts but also responds to child agency and enable them to encounter opportunities online. Enabling mediation is also more frequent for more digitally skilled children. In this respect, 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]). In 2021 only 56% of individuals aged 16-74 in the EU (27 countries) had basic or above basic digital skills, with wide cross-country inequalities (78% or more in Switzerland, the Netherlands, Finland, Norway and Iceland vs. 31% in Bulgaria and 28% in Romania) (Eurostat, 2022[201]).

[24] 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[44]).

219. Evidence on adults' skills suggests that many parents may need support to enhance their digital and non-digital skills in order to facilitate their children's use of digital technologies for learning. Beyond students and their families, sub-central authorities play an important role in supporting successful digital education. Such authorities are likely to be responsible for the implementation of education policies and procurement decisions in more decentralised systems, but also support for the digitisation of schools. While data are lacking on specific involvement of sub-central authorities in the acquisition, management and use of digital technologies for education, the capacity of local leaders and administrators to effectively perform such tasks when required is crucial, and this is another area where data on school leaders' and local administrators' capacity to navigate digital technologies is needed.

Key policy responses and promising approaches

Support and prepare schools for digital education

220. Access to an enabling digital infrastructure, including internet connectivity, adequate equipment and appropriate software, is a necessary condition for the use of digital technologies in schools, as discussed in Chapter 4. While fulfilling these basic infrastructural needs is a prerequisite, however, it is not sufficient for enabling effective digital education. In order to exploit the potential of digital education technologies, schools need to be prepared and supported. This requires strengthening their digital capacity, 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[202]; Costa, Castaño-Muñoz and Kampylis, 2021[203]).

Provide central guidance for schools and develop tools and incentives at the system level

221. Even in contexts where schools enjoy a high degree of autonomy over the selection and 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. 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 (see Figure 2.4) (OECD, 2020[76]; OECD, 2020[75]).

222. 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 2). Likewise, some education systems have developed central libraries offering digital education materials to schools and teachers or video libraries with examples of successful ways to integrate ICT in teaching:

- During school closures caused by the COVID-19 pandemic, the government of **France** facilitated access to 17 banks of educational digital 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 resources. 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 benefited 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[70]).

Invest in the capacity of school leadership

223. Pedagogical leadership plays a key role in driving and sustaining school improvement processes (Pont, Nusche and Moorman, 2008[204]). 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, p. 66 f.[58]).

224. Assessing the degree to which school leaders, teachers, 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 expect from the wider educational ecosystem and should inform interventions designed to strengthen their capacity, including the provision of adequate training (Ganimian, Vegas and Hess, 2020, p. 23[59]).

225. Several European education systems have sought to build capacity within schools' expanded leadership teams to support teachers' use of ICT. According to Eurydice data, about half of European education systems do so with policies that support the appointment of a digital coordinator in schools. Some systems have also 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[205]). Such capacity-building efforts can take different forms, as described below:

- Multiple European countries have created formal positions for teachers tasked with supporting the effective use of ICT in schools, such as the ICT co-ordinators in the **Flemish Community of Belgium** (OECD, 2021[206]) and the **Slovak Republic** (Santiago et al., 2016[207]), or e-learning co-ordinators in **Austria** (Nusche et al., 2016[208]). 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[209]).
- 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 ICT-related counselling and training to school leaders, strengthen professional e-communities, the active exchange of good practice and peer learning (European Commission/EACEA/Eurydice, 2019, p. 94[205]). 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[73]). 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[210]).

Support schools' self-evaluation of their digital capacity and their development of digital education strategies

226. Evaluation practices at the system- and institution-levels can play an important role in improving the use of digital education technologies in schools. The relationship between ICT and evaluation practices is two-sided. On the one hand, ICT can facilitate the implementation of self-evaluations in schools (e.g. principals might use online surveys to solicit feedback from teachers, students and other stakeholders). On the other hand, teachers' 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[30]).

227. Several countries have adapted their evaluation frameworks to account for the use of digital education technologies in schools. In 2018/2019, 10 EU countries had aspects related to digital education included in their external school evaluation frameworks, with varying evaluation methods and data sources (e.g. surveys, classroom observation) (European Commission/EACEA/Eurydice, 2019[205]). 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 3). Enabling schools 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[65]). The Self-reflection on Effective Learning by Fostering the use of Innovative Educational technologies tool (SELFIE), described below, is an example of a centrally developed tool intended to support schools' evaluation of their digital capacity:

- 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[211]). 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[202]; Costa, Castaño-Muñoz and Kampylis, 2021[203]). In 2021, the tool was complemented by SELFIE for teachers, which helps individual teachers in assessing their digital competences and identifies further learning needs.
- **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[73]). Over 400 general education schools had undergone the self-evaluation process between 2016 and 2019 (OECD, 2020, p. 17[212]). 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[213]).

Address equity issues related to digital capacity in schools

228. Enhancing the inclusiveness of 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.

229. 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[168]). While targeted programmes can allow better steering resources for equity resources, they can also translate into inefficiencies and 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[214]). 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 ICT equipment in the classroom (*Équipe mobile académique de liaison et d'animation*, EMALA) (Echazarra and Radinger, 2019, p. 52 f.[215]).

Prepare teachers and other school staff for the effective use of digital education technology

230. While infrastructure investments are a precondition for schools and teachers to acquire digital equipment and tools (see Chapter 4), the effects of using digital education technologies in the classroom are heterogeneous and their positive impact on student learning depends on teachers' ability to use them effectively (Comi et al., 2017[216]). It is therefore imperative for investments in ICT hardware and software to be accompanied by efforts to build capacity in and around schools in order to unfold their potential. The following sub-sections will discuss a range of strategies that can strengthen education professionals' digital capacity, including:

- Integrating the use of digital education technology into initial teacher education (ITE) programmes and supporting continuing professional learning on the subject,
- the adaptation of curricula and the explicit recognition of the potential of digital education technologies to achieve desired learner outcomes (incl. cognitive and socio-emotional skills, digital literacy, well-being and labour market and social outcomes),
- research brokerage and advocacy efforts (described in the previous section) whenever resistance to digitally-enhanced teaching impedes their implementation,
- the recognition of the use of digital education technologies in teaching in the management of teaching staff (e.g. through professional standards, evaluation practices or incentives).

Develop skills for the effective use of digital education technology in initial teacher education

231. Data from TALIS 2018 suggests that many teachers were not prepared for the use of digital technologies as part of their ITE, especially those trained before the digital transformation of school education started. Only 56% of lower secondary teachers across the OECD received training in the use of ICT for teaching as part of their formal education or training, and only 43% of teachers felt well or very well prepared to use ICT at the end of their formal training (OECD, 2019, pp. 207, Tables I.4.13 and I.4.20[32]). 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[217]).
- In **Denmark**, efforts to strengthen teachers' ICT 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 ICTs and basic ICT skills training, and has become a European standard in the provision of ICT 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[218]). In line with an increasing emphasis on students' role as active learners capable of creating with technology (Arstorp, 2021[219]), a new subject – technology comprehension (*teknologiforstaelse*) – was introduced as a subject in 46 pilot schools between 2018-2021.[25] In conjunction, a multiple universities and teacher professional colleges collaborated to develop a corresponding course in initial teacher education programmes in 2020. A 2021 evaluation found the ITE course to have strengthened teachers' content knowledge for the technology comprehension course and, to some extent, their subject 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[220]).
- **France** strengthened the role of ICT-related competencies in its teacher education system to accompany a greater emphasis on ICT in students' curricula. In 2019/20, France introduced new ICT-related courses at the upper secondary level and a new Reference Framework of Digital Competences (*Cadre de référence des compétences numériques*), covering primary, secondary and tertiary education with end-of-cycle assessments. To ensure their ability to foster students' ICT skills, new teachers are required to 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[221]).
- 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.

[25] The school pilot was evaluated in 2021 (Danish Ministry of Children and Education, 2021[326]).

One example of this approach is the university's integration of flipped learning techniques, which is a pedagogical approach based on the intensive use of technology and internet-based resources to improve the personalisation of instruction and ensuring that there is more time in the classroom for meaningful face-to-face interactions. Initial research and development funded by the Ministry of Education (MOE) 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 (KEDI) in all four national evaluations of ITE undertaken between 1998 and 2015 (OECD, 2019[222]).

A lack of training on the use of assistive technologies in pre-service training can contribute to teachers' lack of efficacy in using digital education technologies to support students with SEN. Several empirical studies have shown that attempts to address this shortcoming can improve teachers' knowledge and sense of efficacy in using assistive technologies in schools, although as of yet, there is little evidence on the longer-term effects of such interventions (Atanga et al., 2020[196]):

- 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[223]). Previous studies of similar interventions had found comparable results (Poel, Wood and Schmidt, 2013[224]).

Develop skills for the effective use of digital education technology through continuing professional development, peer learning and communities of practice

232. While teachers' initial education is critical to ensure that new teachers are prepared for their work, continuing professional learning 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[192]). International surveys suggest that teachers' training is an important condition for the effective integration of ICT in the classroom (Gil-Flores, Rodríguez-Santero and Torres-Gordillo, 2017[195]; Fraillon et al., 2014[193]).

233. Effective forms of continuing professional learning (CPL) can help teachers improve their practice throughout their career (Kraft and Papay, 2014[225]; OECD, 2018[226]). Although the literature specifically concerned with CPL on the use of ICT 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[192]). 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[227]; Jacob and Lefgren, 2004[228]; Garet et al., 2016[229]; Garet et al., 2008[230]). Meta-reviews of randomised control trials have echoed concerns about the effectiveness of traditionally delivered professional development (Kennedy, 2019[231]; Kennedy, 2016[232]).

234. Although they remain the exception, new approaches to professional learning have shown greater promise to improve learning outcomes, including school-based, teacher-led improvement projects that focus on classroom practices and emerge directly from teachers' and their students' needs.

New forms of professional learning tend to stress features such as collaboration (Opfer, 2016[233]), the use of external expertise and individualised instructional coaching (Kraft and Blazar, 2017[234]; Blazar and Kraft, 2015[235]) or matching effective teachers with less effective ones (Papay et al., 2016[236]). In a systematic review of the empirical literature, Darling-Hammond et al. (Darling-Hammond, Hyler and Gardner, 2017[237]) 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.

235. At the same time, while the research consensus supports a shift away from passive, standardised, one-off seminar-style courses, none of these design features can guarantee effectiveness in and of themselves (Timperley et al., 2007[238]). 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[236]). 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[238]).

236. In addition to targeted in-service training, peer learning within and across schools and collaboration in communities of practice can be particularly powerful ways to promote teachers' professional growth (Gil-Flores, Rodríguez-Santero and Torres-Gordillo, 2017[195]). Beyond the mastery of technical skills and tools, professional learning should focus on the pedagogical use of technology and on tailoring it to specific subjects and activities (OECD, 2020[33]), or to the needs of specific groups of learners, for example in the case of assistive technologies. Professional learning communities can be highly effective means to promote incremental improvements in teachers' instructional practices and foster innovative teaching (Kools and Stoll, 2016[239]; Stoll et al., 2006[240]):

- The **Australian** Curriculum, Assessment and Reporting Authority (ACARA) defines students' ICT capability as using "ICT effectively and appropriately to access, create and communicate information and ideas, solve problems and work collaboratively in all learning areas at school and in their lives beyond school" and has integrated this capability into curricula across school years and subject areas (ACARA, 2022[241]). 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, pp. 82 f., Box 4.3[150]). This is complemented by free online MOOCs and professional learning events developed by the Computer Science Education Research Group (CSER) 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, pp. 82 f., Box 4.3[150]).
- In **Germany**, the DigitalPact 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[242]; OECD, 2021,

p. 181[73]). A central website provides an overview of professional learning opportunities available online and in all sixteen states (Deutscher Bildungsserver, 2022[243]). 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[244]) and using intensive coaching and communities of practice (Dinse de Salas, 2019[245]) have shown promising effects on teachers' self-efficacy and their integration of ICT in the classroom.

237. Initiatives in several countries have sought to provide high-quality professional learning opportunities to VET teachers to familiarise them with the latest technologies used in the workplace and to enhance their capacity to enhance students' digital skills:

- 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, pp. 143, Box 4.13[36]).
- 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, pp. 142, Box 4.12[36]).
- 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, pp. 144, Box 4.14[36]).

238. 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[191]). 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[33]). In TALIS 2018, a culture of professional collaboration in schools has been shown to be associated with a more frequent use of ICT for instruction (OECD, 2022[51]). 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[76]; OECD, 2020, pp. 221, Table V.B1.5.18[75]).

239. 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[226]). 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[192]).

240. Inter-institutional partnerships, associations or cooperatives 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 2). 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 ICT tools for distance education. In early 2020, the platform had more than 250 000 active members (OECD, 2021, p. 13[206]; Minea-Pic, 2020[194]).
- The European Commission's **School Education Gateway** and **eTwinning** platforms provide education professionals with opportunities to communicate, share practices, create collaborative projects using ICT, access and share resources. In 2022, the two platforms will be merged into the European School Education Platform (European Union, 2022[246]; Kools and Stoll, 2016, p. 43[239]; European Commission, 2022[247]).

Provie resources and incentives for teachers to use digital education technologies

241. Given the effort and upfront investment it can take teachers to enhance their practice with digital education technologies, some education systems provide incentives for teachers to successfully use digital tools in the classroom. Teachers may benefit from financial incentives, career advancement, reduced teaching hours, competitions that award prizes, additional training hours and additional ICT equipment for the classroom (Wastiau et al., 2013[248]). 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 ICT in the classroom.

242. In PISA 2018, 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, pp. 268, Table V.B1.5.15[75]). However, incentives may not be the most effective way to encourage the use of ICT to promote quality and equity in teaching. Incentives need to be carefully designed to avoid the risk of crowding out teachers' intrinsic motivation to engage in the pedagogical use of ICT and to avoid exacerbating existing digital divides within the teacher profession (OECD, 2019[30]; OECD, 2019[171]).

243. To ensure that teachers can use digital devices to enhance their teaching, they also need time and resources. Although the use of digital education technology promises to make some aspects of teachers' work more efficient (see the analytical framework [EDU/EDPC/SR(2023)2]) 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[194]). 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, pp. 268, Table V.B1.5.15[75]). 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[76]; OECD, 2020[75]). Examples of countries providing teachers with resources and incentives to teach using ICT:

- 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 ICT-related 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[249]). Various aspects of the National Plan for Teacher Training (2016-2019), associated with the Good School reform, have been subject to an evaluation carried out by the National Institute for Documentation, Innovation and Educational Research (INDIRE) (Pettenati, 2021[250]). 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[251]).

Prepare the wider learning ecosystem for digital education

244. Successfully implementing education policies and achieving tangible improvements in teaching and learning requires coordinated efforts and capacity building among many actors at multiple levels of the educational system (Viennet and Pont, 2017[252]). The form that capacity building efforts should take across the wider learning ecosystem 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 tertiary level).

Build students' skills for digital education

245. Beyond general policies to enhance the quality and inclusiveness 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 ICT 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[85]).

246. 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, and resilience online. There has also been a trend, observed in some countries, to integrate ICT 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 ICT as cross-cutting content across multiple subjects or the entire curriculum (OECD, 2020[253]).

Support parents and caregivers as digital education facilitators

247. In addition to providing school-based support to students for their use of digital learning technologies through curriculum and ICT training, home-based support for parents and learners 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 ICT training of adults and caretakers in the community; providing ICT 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[254]) (see Chapter 1 for further examples of holistic system-wide approaches to digital skills).

248. 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[255]). 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.

249. 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[256]). 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[257]).

250. 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 educational 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[258]).

251. 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 such programmes are known from potential beneficiaries. 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).

252. 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[259]). 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 local and sub-central authorities with responsibility for digital education

253. When sub-central authorities have a key role in supporting digital education (e.g. through the acquisition of digital resources for schools 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 schools, 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[169]). 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 advisers 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 adviser, 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[120]).

7 Monitoring and evaluation for digital education

This chapter assesses the current use and potential of monitoring and evaluation of digital education. Monitoring and evaluation are integral to ensure the quality of digital education and its effective contribution to educational outcomes. As such, they must be aligned with the strategic goals for education digitalisation and be formally anchored in monitoring and evaluation frameworks. Education ministries must also ensure the extensive monitoring of all enabling factors for digital education including connectivity, the digital equipment available at schools and the capacity of schools and teachers to implement digital education. To provide a comprehensive picture of the state of digitalisation, monitoring must draw on a range of data and evidence sources such as national data collections, international surveys, school quality evaluations or research findings. This chapter aims to inform policies for the monitoring and evaluation of digital education by reviewing the evidence and data sources that are currently available and putting forward promising policy examples from OECD education systems.

State of play

Significant information gaps persist on policy progress along most dimensions of digital education

Information regarding the availability of infrastructure and technology for digital education is limited

Current budgeting and accounting practices do not permit the reliable identification of digital infrastructure spending

254. As observed in Chapter 5, little information is available at system level about the extent of investment in digital infrastructure in education. 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 yet unrelated to digital education. In this context, it is difficult to rely on government budget's line items to track digitalisation spending.

255. 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 of it falls under either 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 to digital infrastructure.

256. Special efforts have been made to create one-off spending estimates in some countries. For example, an **Irish** 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[260]).

257. Estimates of expenditure in public schools and vocational training institutions could be easier to obtain, given that, on average across OECD countries, 90% of school funding originates from public sources (OECD, 2022[261]) . Nevertheless, a 2019 survey of European countries revealed the difficulty of reliably identifying the share of public funds invested in digital infrastructure for school education (European Commission/EACEA/Eurydice, 2019[5]). Estimates from market research companies are only available for a limited set of jurisdictions. For example, estimates from the **United States** indicate that among the 77 largest urban public school systems the median district spends around 2% of its budget on network services, computers and devices, technical support, systems and software (Council of the Great City Schools, 2020[126]).

258. A lack of transparent information on the extent of expenditure on digitalisation limits capacity for long-term planning, or even arriving at a reasonable target for expenditure on digital technologies. It also precludes attempts to link expenditure to results and outcomes to assess the extent of efficiency gains deriving 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.

259. 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[262]). While the Indicators of Education Systems (INES) Working Party has not examined the development of digital education expenditure indicators yet, digitalisation in education will likely be one of the data innovation areas proposed to INES participating countries as part of the forthcoming biannual prioritisation process given the prominence of digitalisation in many countries' (and the OECD corporate) priorities and strategies.

While Internet connectivity is relatively well-monitored at system level…

260. 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 rollout and inequalities in connectivity (OECD, 2022[263]). 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 at all education levels

261. 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, including their technical equipment and local area network capacity.

262. Still, 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 2021, for example, **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[264]).
- 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 ICT infrastructure (European Commission/EACEA/Eurydice, 2019[5]) (Heymans et al., 2018[265]).

263. 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[266]; European Commission, 2013[54]). 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[267]).
- 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, country coverage remains limited (OECD, 2022[51]) (OECD, 2019[32]) (OECD, 2020[33]).

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. 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[268]), monitoring the availability, use and condition of digital equipment can help to structure and inform future research on its effect.

Little evidence exists on the effective use of digital technologies

Research on the effective use of digital technologies in education is fragmented…

264. Many studies have been conducted on the impact, and to some extent on the cost effectiveness, of digital technologies. As pointed out in the analytical framework [EDU/EDPC/SR(2023)2] , 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.

265. As shown in the introduction, 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.

266. 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

267. In a fast-changing technology environment, evidence on the effectiveness of the usage of some smart technologies' risks becoming rapidly outdated (OECD, 2021[52]). 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[269]). 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.

268. 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.

269. 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 educational technology, then information is needed on emerging technologies as they are being established, not after they have been adopted (OECD, 2021[270]).

270. 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 and trends to assess 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 and more data development for monitoring is underway

As infrastructure barriers have been reduced and digital education technologies have permeated education systems, schools' and teachers' capacity for digital education has emerged as a key challenge to realise their full potential

271. As discussed in Chapter 2, digital education technologies – if used effectively – hold potential to enhance teaching and learning, support efforts to improve equity, and generate cost savings. This has provided impetus to a significant expansion of digital education infrastructure in schools. However, as infrastructure barriers have been reduced and technological possibilities for ICT-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[7]; OECD, 2021[151]). 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. Accordingly, schools and teachers' capacity has been a strong area of focus for studies and surveys dealing with digital education.

A range of international surveys and assessments shed light on the capacity of institutions and education staff for digital education…

272. 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 ICT-related professional development (European Commission, 2019[266]; European Commission, 2013[54]).

273. 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[271]) (OECD, 2015[272]) (OECD, 2020[273]) (OECD, 2021[274]) (OECD, 2022[275]). 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.

274. 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

275. Chapter 3 has 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 cybersecurity and data protection.

276. 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[276]). 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 (ICO). 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

277. Careful monitoring and evaluation are crucial for supporting innovation in the use of digital education technologies (Redecker et al., 2017[277]). 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[278]).

278. Accordingly, and as discussed in Chapter 1 a number of new or updated national-level strategies for digitalisation in education have been introduced, some of which have been backed by specific funding, governance and implementation arrangements. Across Europe, many recent digitalisation policies within education systems included specific indicators or other measures aimed at assessing the implementation and the impact of the initiative. For example:

- 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[279]).

- **Spain's** *Educa en Digital* strategy aims to close gaps in access to digital education technologies, implement AI tools for more personalised learning and tracking of student progress, and improve the digital competences of teachers. The implementation of the strategy is monitored by a designated Committee. All projects progressed under the umbrella of the strategy are monitored using a series of mandatory indicators, including the number of new equipment items made available to education institutions, the number of AI projects implemented, and the number of students and education institutions targeted for improvement (BOE, 2020[280]).
- The **Swedish** national digitalisation strategy for the school system mandates follow-up reports on its impact, through surveys carried out in schools by an external body (Skolverket, 2021[281]).

279. Outside of evaluating specific policies during or immediately after their period of implementation, there are few indications that more systematic and persistent attempts to monitor and evaluate digitalisation are being made, although more recent evidence shows promising developments in this area, at least for school education. Table 7.1 below 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[5]). However, information from the 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. While a provisional stock take of monitoring and evaluation policies across OECD education systems is available in Annex 7.B, the following examples illustrate some promising initiatives:

- 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 school's increase of maturity level (Balaban, Begicevic Redjep and Klacmer Calopa, 2018[282]). The pilot project covered 151 schools, and evaluations indicated that almost 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 program for the development of staff digital competences (Centre for Applied Psychology at the Faculty of Philosophy in Rijeka, 2018[283])
- In **Portugal**, an online platform was created 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.[284]).
- 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[265]).

280. 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.

Table 7.1. Existence 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**
Countries	(European Commission/EACEA/Eurydice, 2019[5]).	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[2]	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)	Missing
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)	Missing
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.
Source: Eurydice (2019[5]), 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.

Key policy responses and promising approaches

Create an enabling monitoring and evaluation infrastructure for digital education

281. A key conclusion of Chapter 1 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 to permit revision of the strategy. At a national level, this vision is best achieved through a process of wide consultation to agree on the elements of the monitoring framework (OECD, 2013[285]). 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.

282. 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[278]). 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.

283. However, 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 their schools' digital maturity against objectives or benchmark education systems. But 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).

284. 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 resources constraints and burden on institutions, and thus use or adapt existing data resources as much as possible, carefully balancing the benefits of new data collection with its associated administrative and financial cost and burden on the system.

Develop a national framework for monitoring and evaluating digital education…

285. 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 ICT adoption 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[286]). 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.

286. 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. A growing number of education systems thus work on developing a stronger evidence base on the permeation and impact of digital education, and evaluate the effectiveness of different digital pedagogical approaches, learning resources or tools.

- Illustrating this trend, the Schools Digital Strategy of **New South Wales in 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. But 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.[287]).
- 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[288]).

287. Likewise, the examples described above from the **Flemish Community of Belgium**, **Ireland**, **Spain** or **Sweden** illustrate countries' digital strategies that have a strong monitoring dimension embedded in policy design.

288. 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[289]; OECD, 2020[290]), 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.

289. A national monitoring and evaluation framework should also ideally provide insight into 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[289]).
- **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[291]).
- **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 technologies 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[5]). 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[292]). 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[292]).
- **Portugal** can also provide a source of inspiration as a country that is leapfrogging its digital transformation (Estevez et al., 2021[293]). Digital education is embedded within a broader digital transformation strategy which comprises three main pillars of action: 1) Capacity building and digital inclusion; 2) Businesses' digital transformation; and 3) Public services' digitalisation; as well

as an additional catalyst dimension to create the proper conditions to accelerate the country' s digital transformation (Portugal, 2020[294]). What makes the approach distinctive is that a comprehensive action plan has been developed through a consultative process across government areas, a monitoring framework has been designed, and a specific structure (*Portugal Digital*) established to ensure the global coordination of the action plan, the links with the different agencies and structures involved in the measures, the roll out of their implementation and the reporting of the results of the action plan. 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[26].

… building on the national vision for digital education and taking into account broader social goals connected to digitalisation

290. 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.

291. The analytical framework of this publication itself can also serve as a foundation for monitoring and evaluation. Due to the international context for this project, the monitoring framework will inevitably be broader and more general than would be the case for a national monitoring framework intended to gauge progress on a more reduced set of strategic objectives. That said, the analytical framework underlying this publication provides a comprehensive and systematic overview of dimensions along which progress in digitalisation can be measured:

- the effective use of digital technologies through adequate pedagogies, curricula and assessment frameworks
- presence of the necessary guidance and a regulatory framework for digital education
- the provision of essential preconditions for digital education
- the availability of the necessary resources for digital education
- the capacity of educators, institutions and at a system level to implement education policies

292. The impact of policy reforms along these dimensions should then be assessed in terms of access and equity, quality and efficiency. As mentioned earlier in this chapter, data constraints particularly on investment levels in digital education might stand in the way of reliably measuring efficiency of digital education in the short to medium term. At the current stage of data development, a first step with respect to the efficiency dimension would be to capture and monitor some of the building blocks towards efficiency analysis: such as levels of spending or outcomes achieved.

293. 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[262]), namely:

- Making the digital economy visible in national accounts/statistics

[26] See: https://observatorio.incode2030.gov.pt/o-observatorio/ (Accessed on 22 February 2023)

- Understand the impacts 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.

Potential sources of evidence for the development of national monitoring and evaluation infrastructures

294. A national monitoring and evaluation framework can draw upon a number of 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.

Harness the potential of national data collections

Add a 'digitalisation lens' to national administrative and statistical data collections where possible

295. 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 (UOE) 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.

296. A major limitation of many existing 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[295]). Currently, only few countries collect data from individual students that can be harnessed to generate information on some aspects of digital education and create more adequate control groups:

- 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 foster evidence-based decision-making (OECD, 2020[292]).
- 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 ICT 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[283]).

Consider expanding and repeating existing national data collections on digitalisation in education

297. As concluded earlier in this paper, 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.

298. 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.[296]).

299. 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[5]). 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[297])

Relevant international indicators could be integrated into national monitoring and evaluation frameworks

300. Countries are increasingly interested in comparing their performance on digitalisation with other countries, as part of national monitoring and evaluation efforts (Trucano, 2019[298]). 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.

General indicators of digital performance

301. 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[262]).

302. Most existing measurement frameworks aim to assess progress on digitalisation across a broad range of economic and social sectors (Table 7.2). 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 (NRI) by the Portulans Institute ranks 130 global economies on technology development and the ability of countries to capitalise on ICT opportunities. It is a composite index based on four primary pillars: technology, people, government and impact. The IMD World Digital Competitiveness Ranking 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[299]).

303. 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 (Commission, 2022[300]). Another example of a European framework is the Centre for European Studies' Index of Readiness for Digital Lifelong Learning (IRLL) which measures three key dimensions: learning participation and outcomes, 2) institutions and policies for digital learning and 3) availability of digital learning (CEPS, 2020[301]).

Table 7.2. 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 digitization 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 (labor 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

304. 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[302]; Hu'o'ng, 2022[303]). It could thus provide an additional source evidence on the readiness of various school systems for digital education in the future.

305. Some of these frameworks include one or more components that may also be adopted as indicators of progress related to specific aspects of digital education strategies.

Comparative policy indicators

306. 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.

307. 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[304]) and the OECD Education Policy Outlook (OECD, 2018[242]). 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.

308. 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 (EACEA) 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[5]). In the context of preparing this document, the OECD has worked on updating some of its elements as presented in Chapter 0.

309. 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 vocational education and training (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.

International surveys or assessment indicators

310. 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 to the extent that 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 the ground, while yielding estimates of various indicators at the system level.

311. 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.

312. 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 enable trends over time to be developed. 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.

313. 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 benefiting 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 7.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

314. 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[57]).

315. School inspections 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[305]).

316. Increasingly, inspection reports contain insights into the access and use of digital technologies:

- In **Slovakia**, for example, the State School Inspectorate's (SSI) central evaluation framework includes the use of ICT for teaching as an explicit criterion for the evaluation of education facilities and resources in schools (European Commission/EACEA/Eurydice, 2015, p. 153[306]).
- 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 use of digital technology in education (Scottish Government, 2016, p. 29[307]).
- In **New Zealand**, the effective use of digital devices and ICT resources for learning is listed as one of the indicators for 'Leadership and Excellence' assessed in school evaluations (Education Review Office New Zealand, 2016[308]).

317. 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[309]).

318. 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. 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[310]).

Support the generation of research evidence on the impact of digital education and promote greater use of research insights

319. 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 sections, 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[311]).

320. 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. 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[312]).

321. 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.[313]), the Danish Clearinghouse for Educational Research (DPU, 2022[314]) 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, UK and Ireland, and South Asia (Campbell Collaboration, n.d.[315]).

322. 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 (HTA) organisations, whose mission is to review evidence and provide an assessment of the value of health technologies, are commonplace (INAHTA, n.d.[316]).

323. 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.[317]). 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[318]). 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 ICT 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

324. 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. he 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[319]), 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.

325. In fact, digitalisation involves new measurement opportunities: combined with student outcomes data, the rich data generated by learning management systems (LMS) and virtual learning environments (VLE) 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 educational technology 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.[320]).

326. 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[321]). 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 the engagement with at-risk students, rather than fully automating them (OECD, 2021[52]). 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[322]).

327. 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[323]).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[301]).

Annex 7.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[266]; European Commission, 2013[54]).

  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. There are currently no plans for a further survey round.

  ESSIE focuses on the primary, lower secondary and upper secondary levels of education, and consists of an online survey, and interviews of with head teachers, class teachers (one teacher at ISCED level 1, 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[267]).

  ICILS is administered every 5 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[51]) (OECD, 2019[32]) (OECD, 2020[33]).

  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 5 years since 2001. The following rounds were administered in 2006, 2011, 2016, and the fifth round took place in 2021.

  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[324]).

  TIMSS is administered every 4 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 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 7.B. National Monitoring and Evaluation of High-Level Education Digitalisation Strategies by Country

Annex Table 7.B.1. Monitoring and evaluation provisions of high-level education digitalisation strategies by country

Country[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 BMBWF. 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[265]).
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	Missing
Czech Republic[C]	Missing
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. However, at the time of the release of the report the members of the council have not yet been appointed.
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 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. 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 competencies.
France	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 digitalization initiative 'Digipakt'.
Greece	n/a
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 suggestions 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	Missing
Malta	Missing
Netherlands	Missing
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	Missing
Spain[C]	In Spain, monitoring and evaluation provisions for education digitalisation are captured in the cooperation plans #EcoDigEdu and #CompDigEdu. While the provisions set out key indicators that 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

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