3 Pedagogical approaches, curricula and assessments for digital education

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

Introduction

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

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

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

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

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

Recent developments and current challenges

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

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

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

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

To what extent are digital technologies being used in instruction?

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

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

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

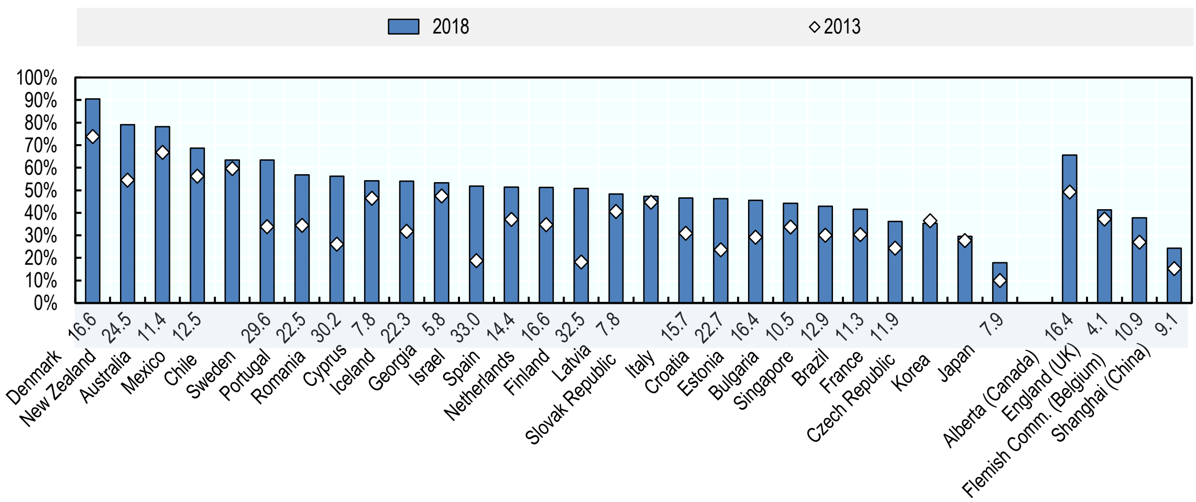
Level of automation	Distribution of control and functions of technology	Examples of technologies
Level 0 (Teacher only)	Teacher controls	Technologies that are fully teacher controlled, without organising function
Level 1 (Teacher assistance)	Teacher has full control; Technology provides supportive information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

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

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

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

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



Notes: These data are reported by teachers and refer to a randomly chosen class they currently teach from their weekly timetable; Only countries and economies with available data for 2013 and 2018 are shown. Countries and economies are ranked in descending order of the prevalence of teachers letting students use ICT for projects or class work in 2018.

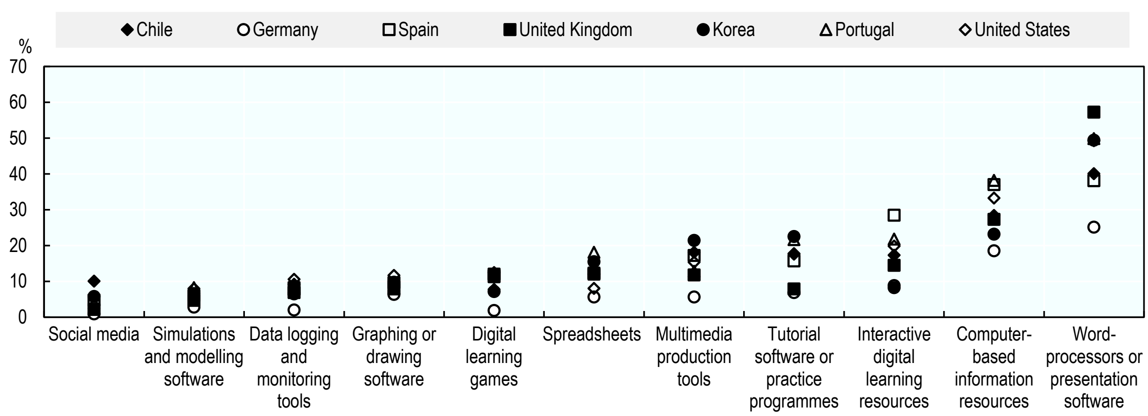
Source: OECD (2019[14]), TALIS 2018 Results (Volume I): Teachers and School Leaders as Lifelong Learners, https://doi.org/10.1787/1d0bc92a-en, Table I.2.4.

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

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

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

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



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

StatLink https://stat.link/4hi0uo

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

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

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

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

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

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

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

How are digital technologies integrated into teaching and learning processes?

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

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

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

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

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

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

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

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

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

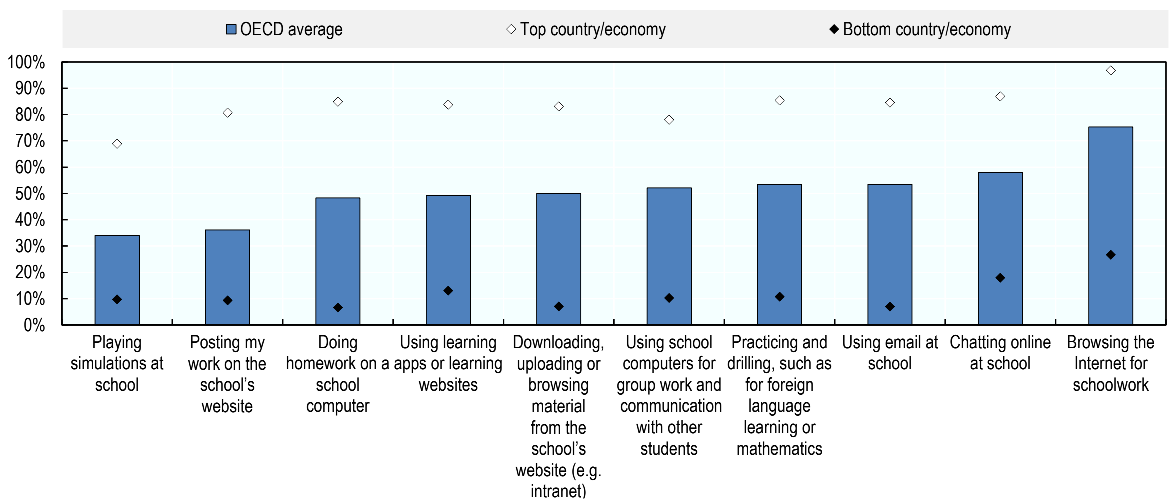
Note: The table summarises classrooms' "best" use of technology by tabulating those classrooms whose highest rating over segments, lessons and observers was a 1 (no technology used), 2 (technology used for communication only), 3 (technology used for communication and limited conceptual understanding)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

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

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

Figure 3.3. Frequency of activities on digital devices in school

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



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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Support education institutions and educators in selecting digital education technologies

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

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

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

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

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

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

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

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

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

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

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

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

Spread good practice and innovations by facilitating peer learning

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

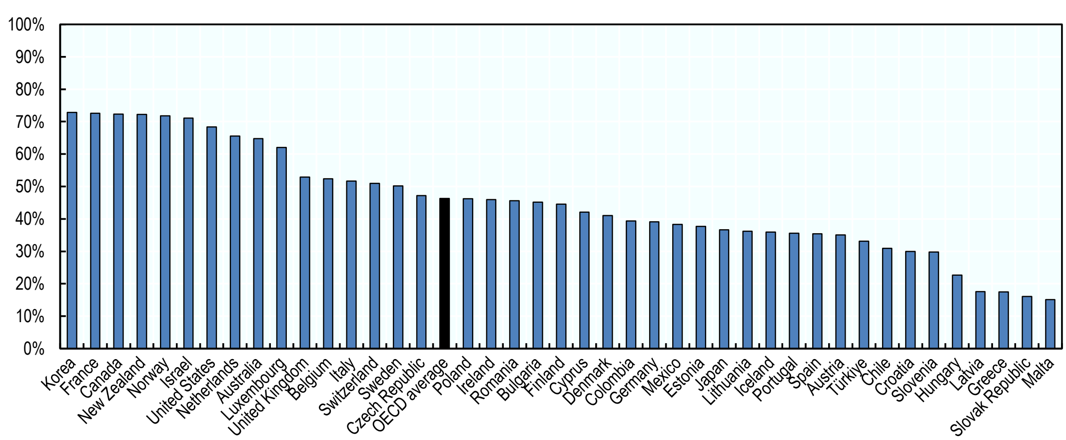
- The *Enlaces* programme in **Chile** aimed to develop teachers' digital skills and promote teachers' attitudes conducive to the use of digital technologies in classrooms. In 2018, the programme gave way to a new Innovation Center at the Ministry of Education, which broadened its mission to explore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

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

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

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

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



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

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

Adapt curricula and assessment frameworks

…to leverage the potential of digital education technologies

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

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

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

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

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

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

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

…to promote digital skills

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

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

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

Key messages

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

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

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

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Notes

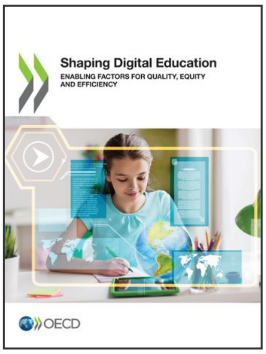
[1] For the purpose of the analysis of TALIS data, VET teachers were defined as those who reported teaching practical and vocational skills in the survey year, regardless of their type of programme or school. This data was available for Sweden, Portugal, Denmark, Slovenia, Canada (Alberta) and Türkiye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

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

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

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

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



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