OECD DIGITAL EDUCATION OUTLOOK 2023

Towards an Effective Digital Education Ecosystem

OECD

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TOWARDS AN EFFECTIVE DIGITAL EDUCATION ECOSYSTEM

OECD
BETTER POLICIES FOR BETTER LIVES

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Foreword

The 2023 Digital Education Outlook provides, for the first time, a window into how OECD countries and partner economies are managing the digital transition and the extent to which they are prepared for a digital transformation.

A digital transition in education has been underway for decades but accelerated significantly during COVID-19 pandemic, when many education systems shifted to remote learning. The transition is characterised by the adoption of student information systems, online learning platforms and the use of digital devices in classrooms.

This transition, however, is not the same as a digital transformation. The latter would imply a fundamental change in some educational processes, integrating technology not just as a tool, but as a way to reshape teaching methodologies, learning processes, and the educational ecosystem at large, to make it more effective. Currently, the incorporation of technology in education often replicates traditional methods rather than reinvents them. The main benefit of a digital transformation lies in the personalisation of education, both in terms of learning and of student support.

65% of OECD countries have a national student information system. The US state of Colorado, for example, runs a public website called SchoolView that provides information and analysis from its longitudinal education information system. The portal provides a social network for teachers, a learner centre and resource bank, interactive school performance charts and access to performance data and reports.

Yet Colorado is an outlier. Few jurisdictions or countries link their student information systems with individual evaluation results or provide dashboards or visualisation tools to make the data more useable in real time. Privacy concerns and a lack of data linkages in many countries prevent information collected about students, teachers and schools to be translated into actionable information to improve education.

Or consider learning management systems – the tools to manage student attendance, classes, contacts and content. Most schools within OECD countries use learning management systems at all levels of school education, yet few are interoperable with system-wide student information systems or with the other digital tools they use.

Interoperability is crucial. Otherwise, it limits data collection and analysis at the jurisdiction or national level and creates inefficiencies as data is manually re-entered across systems and jurisdictions. Countries that provide their schools with a national learning management system are able to leverage system-level functionalities while collecting the data that they need to monitor and improve the education system. In Iceland, for example, the INNA system is both a learning management system for upper secondary schools, allowing for student tracking, timetables, communication with students and parents and handling of school fees, as well as a student information system for the government.

At a more fundamental level, a digital transformation cannot take place unless access to stable, high-speed Internet is ubiquitous. Reliable connectivity is key for students to fully enjoy digital, personalised, and engaging learning through digital solutions, for them to communicate with their teachers or tutors, and to receive timely feedback on their activities.

Faster and better internet throughout all levels of education is a policy priority of almost all countries. Yet how systems use digital devices and resources in schools also bears consideration. According to the 2022 PISA study, students who spent up to one hour per day on learning on digital devices outperformed those who did not by 14 points, even after accounting for socio-economic status. Yet many students reported being distracted by digital devices in the classroom, and this had a negative impact on performance.

The role of teachers thus remains central within any digital transformation. They are the agents who will help students navigate the digital world, not only from a technological adoption standpoint but also in terms of inculcating the behaviours and values necessary to regulate the use of digital devices and adapt to an increasingly data-driven world.

Yet many teachers feel unprepared to in this respect. Across the OECD, around 20% of secondary education teachers report the need for further training despite 60% of teachers having undergone digital education training in the past year. With rapid advances in AI and other digital technology, this is easy to understand. Yet most directives on professional standards with respect to digital competencies remain broad and high-level, leaving significant room for interpretation on how systems understand, develop and evaluate these skills in practice.

Systems like Austria's Digi.kompP model, conversely, provide a clear framework for eight digital competency areas and a progression model to guide teachers throughout their professional development. Micro-credential systems, like that offered by Digital Promise in the US, offer another model to provide credentialed learning across a wide range of digital competencies.

Recent rapid advances in generative artificial intelligence will likely disrupt many aspects of digital education. This transformative technology has the capacity to democratise autonomous learning experiences, providing support tailored to the needs of individual learners and redefining how, where and what students learn.

Yet, today, few OECD countries are prepared to understand or guide the use of generative AI in education. Although all reporting countries and jurisdictions noted that use of generative AI is already widespread, none of the 18 countries for which we have comparative information has issued a regulation on the use of generative AI in education and only nine countries or jurisdictions have published non-binding guidance.

This edition of the Digital Education Outlook outlines a set of opportunities, guidelines and guardrails for the effective and equitable use of AI in education, developed together with Education International, a global federation of teachers' trade unions, that is intended to guide countries and jurisdictions as they decide whether and how to integrate generative AI into their education systems.

These guidelines are essential to ensuring that AI tools are used responsibly and ethically, safeguarding against biased content generation, data privacy breaches, and unintentional reinforcement of stereotypes. The guidelines underscore the need for effective dialogue between education authorities and teaching professionals to ensure that teachers can maintain their role as the guiding force in the learning process while harnessing the potential of AI in education.

Above all, for the digital education transition to become a transformation, governments need to adopt a system-wide approach that strengthens the coherence of the tools, technologies, actors and entities across their education system. I hope that the analysis and insights offered by 2023 Digital Education Outlook provide OECD Members with useful resources in this respect.

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Stéphan Vincent-Lancrin, Senior Analyst and Deputy Head of Division at the Organisation for Economic Co-Operation and Development (OECD), edited and overviewed this book. The book is an output of the OECD Centre for Educational Research and Innovation (CERI) project on “Smart data and digital technology in education: AI, learning analytics and beyond” that he leads.

The chapters of the book have been authored by the following members of the OECD Secretariat and external experts, as indicated for each chapter in the book: Stéphan Vincent-Lancrin (Senior Analyst, OECD), Quentin Vidal (Analyst, OECD), Natalie Foster (Analyst, OECD) Tiago Fragoso (Analyst, OECD), Carlos González-Sancho (Analyst, OECD), Hyunkyeong Yun (Intern, OECD), Jun Yu (Associate Professor, National University of Singapore, Singapore, former Analyst, OECD), Ryan Baker (Associate Professor, University of Pennsylvania, United States), M. Aaron Hawn (University of Pennsylvania, United States), Seiyon Lee (University of Pennsylvania, United States), Inge Molenaar (Director, National Education Lab AI, Radboud University Nijmegen, Netherlands), Peter Sleegers (BMC Consultancy, Netherlands), and Lucia Delagnello (Consultant, former Director of Center for Innovation in Brazilian Education, Brazil).

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OECD-Education International “Opportunities, Guidelines and Guardrails”

Chapter 16 of the book reproduces a document that was jointly developed by the OECD Secretariat and Education International (EI) as a sequel to their ten principles on Effective and Equitable Educational Recovery (2021) which drew on the lessons of the pandemic and compiled policy experiences and practices from countries in order to inform work on a sustained educational recovery.

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Executive Summary

The COVID-19 pandemic has shown the potential and need to be ready for digital education. Countries have digitised their system-level management tools to some extent, but coherent digital education ecosystems still remain to be established in many countries.

The Digital Education Outlook 2023 proposes thematic and comparative analysis of OECD countries' digital ecosystem and governance, and highlights different opportunities and challenges to achieve different policy objectives. Taken together with its companion report, *Country digital ecosystems and governance*, that provides in-depth information about 29 countries/jurisdictions, it provides a state of the art of digital education in the OECD area, and a baseline to measure progress in the decade to come.

Part of the information in this book comes from a systematic survey of OECD countries and Brazil regarding their digital education infrastructure and their governance of education as of December 2023, desk research, as well as past work by the OECD Centre for Educational Research and Innovation on technology, innovation and research in education. The book provides policy considerations for countries to enhance their digital education ecosystem and governance and highlights some of the tensions between different policy objectives. It is fully informed by the *OECD Digital Education Outlook 2021: Pushing the frontiers with AI, blockchain and robots*, which allows to measure the gap between what could be possible and where countries stand.

This report has two main parts: one about countries' digital education ecosystem, including its human component, and one about its governance. The third part is devoted to a position paper on AI in education written by the OECD secretariat and Education International, the international federation of teaching unions, aiming to facilitate a dialogue between public education authorities and the teacher profession and their representatives to collaborate on the digital transformation.

Digital education ecosystems

Digital education ecosystems consist of three parts: digital tools for system and institutional management, digital tools for teaching, learning and assessing in the classroom, and human beings that make these tools alive and meaningful. The pandemic raised a big question: what is the minimal infrastructure a country should provide to its schools, teachers and students for learning to continue in case of a disruption, but also generally speaking? Another observation it made visible is the gap between what would be possible to make education more effective and equitable if teachers and students were augmented by digital education, including AI, and what countries, educational authorities or schools provide as of 2023.

System-level management tools

The cornerstone of a digital education infrastructure at the system level lies in a longitudinal student information system. A second best is to have a central student register with unique longitudinal identifiers for students (and possibly teachers). Student information systems allow the entire education system to benefit from information that is gathered at the national level if and when it can be turned into actionable information for local stakeholders. At the least, the information gathered will allow generating evidence that may inform education policies within countries. As of 2023, most OECD countries have established a student information system, although they still use it mainly for statistical purposes rather than as a way to provide real-time information to stakeholders (chapter 2).

The equivalent of student information systems at the school level are learning management systems: they allow schools to manage and track information about individual students, which classes they attend, with which teachers, and, in some cases, to access digital content for teaching/learning. Ideally, they should be able to “push” and “receive” data to and from their jurisdictional student information system. While most countries report that most of their school use such systems, at least to some extent, in about half of them learning management systems are not interoperable with system-level student information systems and require schools to manually provide information to their public authorities/ministries. They are also unable to receive any insight from the data collected at the jurisdictional level.

The report shows that most countries provide study/careers guidance information through digital means, even though few of them provide tools for more personalised enquiries, and that most national evaluations are digitised or in the process of being so. Digitising actual high-stakes exams for students is a different story, and while a few OECD countries are exploring this path, only few of them have done it (Finland is an example). A few countries have digitised some aspects of the administration of their paper-and-pencil exams as well as their selective admission processes into higher education (and sometimes high school) (chapters 3 and 4).

Digital ecosystems for teaching and learning

A second question is about the digital learning resources that are accessible by teachers and students. This is another issue that the pandemic has made salient and that led to many new promising initiatives within countries.

The OECD, alongside other international organisations such as UNESCO, have long encouraged countries to develop platforms of open educational resources (OERs). OERs tend to be available free of charge to all citizens speaking a given language. MOOC (massive open online courses) platforms have also expanded that offer, as is the case for TV and radio education and social network channels in selected countries. Most of these offers were boosted by the pandemic and are still available in some countries.

Another way for countries to support teachers and students is to license digital learning and teaching resources from education publishers or to enable schools/municipalities (etc.) to buy their resources from them. The advantage of a central provision is that central governments have in principle more capacity to quality assure resources. On the other hand, schools or local governments may be better placed to choose what suits their students. In any event, while having a baseline of “free of charge” or open resources is important to allow everyone to benefit from public education, private providers remain overall better placed to keep learning resources up do date and should certainly remain part of the public provision/procurement equation (chapter 5).

Digital competences

A strong digital education ecosystem encompasses students and teachers who can use the digital tools and resources at their disposal. There is no point in providing resources that are not effectively used by teachers and students. Countries incentivise teachers to develop their pedagogical digital competences in different ways: some have digital competency standards that pre-service teacher education programmes have to follow; others issue guidelines that sub-government authorities may or may not follow; others mandate regular in-service teacher training and provide teacher professional learning resources. Many include “digital competences” as an objective in their national/jurisdictional curriculum and hope that teachers and teacher pre- and in-service professional learning will adjust (chapter 7).

Physical infrastructure

Too many digital education strategies have been limited to the physical digital infrastructure, that is high quality connectivity and enough devices for students and teachers to access. This is obviously still a prerequisite to embrace the opportunities of digital education. While this Outlook reports on that very important element, it did not start with it to make it clear that this is not the only important or necessary element of a strong digital education ecosystem. Just providing digital devices and good connectivity will not lead to a digital improvement of education. Most of the elements mentioned above are the drivers of such a transformation, even though it can only take place where hardware is available. This has been a key priority of countries' digital strategy in the recent past (chapter 6).

Access, use and governance of digital technologies and data in education

Equality of access and use

The COVID-19 pandemic exposed inequalities in access to the physical and "soft" digital education infrastructure. In normal times, almost all countries experience significant differences in terms of access and exposure to digital learning resources and tools. This is mainly due to the devolution of responsibilities within countries, which allows sublevels of governments to decide on the appropriateness or affordability to provide, encourage or support the use (and/or procurement) of digital tools and resources by schools, teachers and learners. Some countries have put in place ambitious programmes to incentivise all sub-governmental entities to invest in digitalisation. Others have managed to do so with no policy, but a "like-mindedness" across the country. And others just witness big disparities between "frontrunners" and "laggards", whether by choice or by force. Providing equality in access and use, and equity for populations that are less likely to be able to benefit from digital education without intervention, will remain a key challenge for governments in the near future (chapters 6 and throughout).

Data and technology governance

Another challenge relates to governing digital technology and data in order to generate public trust while keeping market incentives for commercial education technology companies and education publishers to develop appropriate tools and resources for the education sector.

Privacy and data protection, including cybersecurity, are key to data governance. All OECD countries have developed data protection and privacy regulation about access to and sharing of administrative education data. In many cases, countries have also developed specific legislation or rules about education data, in relation to their system-level student information and other administrative systems. While the regulation usually extends to commercial providers and prevents them from sharing data, no country has put in place any regulation or contract to access data that are collected by commercial providers within public schools. There are also no regulation or guidelines about algorithms or automated decisions (apart from government-wide decisions or guidelines where they exist), perhaps because automated decisions hardly exist anywhere in the OECD area. There is also no country that reports any high- or medium- stakes AI-empowered tool or resource in education as of 2024. AI resources will typically be embedded in adaptive learning systems or in the recent emergence of generative AI applications (based on large language or other types of models), for which an increasing number of guidelines are being developed (chapters 8 and 10).

Discussion about algorithmic bias should increasingly influence regulation in countries where equity is a high policy priority. Algorithmic bias refers to cases where an algorithm advantages some populations compared to others (whether the characteristics relate to gender, race and ethnicity, migration status, etc.). Research on algorithmic bias is mainly undertaken in the United States, including for algorithms and systems operating outside of the United States. An important take-away from this research is the importance to collect personal (and sometimes sensitive) data within strong data protection and privacy policies to be capable to detect (and thus address) algorithmic bias (chapter 9).

Interoperability

A second aspect of data and technology governance lies in interoperability standards and the mandate or incentives to use some of these standards. For a variety of reasons, including “legacy” systems and the distribution of responsibilities across multiple education agencies, sub-government levels and departments within a ministry, many digital education tools do not have the capacity to exchange and link data. This implies education staff often have to re-enter data multiple times and a significant share of the data collected at the system level remain dormant rather than being used for educational improvement and intervention. Another aspect of interoperability lies in the development of standard taxonomies to tag digital learning resources (semantic interoperability). Many countries have started to attempt to unify their digital ecosystem for users by providing a “single sign-on” service, but most still do not have interoperability between school-level and system-level management tools (or even between system-level management tools) (chapter 11).

Procurement

A third aspect of data and technology governance lies in procurement rules and regulation. As of 2024, more centralised countries tend to provide a framework for public procurement and pre-approve most of the digital education tools and resources that schools and teachers can procure, when they are not procuring themselves. More decentralised countries tend to leave the decision to schools or local authorities, but rarely provide guidance on what to procure. The procurement of digital tools and resources is also not conditioned on any particular outcomes other than data protection and security, contrary to what is observed in the health sector for example (chapter 12).

Supporting innovation and research and development (R-D) in digital education

Supporting the development and improvement of digital education tools and resources as well as research on the effective uses of digital education are two important dimensions of a strong digital ecosystem and governance in education.

Traditional education stakeholders do usually not have the competence to develop digital tools for the education sector. Typically, those are developed by for-profit education technology companies, sometimes specifically for the education sector, sometimes by adapting tools that were developed for other sectors to education. It is rare for education ministries to support directly commercial companies, although education technology may benefit from governmental innovation programmes (e.g. for startups or for research and exploratory development). While a few support their education technology industry from an international trade perspective, many engage in a dialogue with them by supporting conferences, etc. Education authorities also collaborate relatively rarely with stakeholders such parents or students when developing or introducing new digital tools and resources.

While governments sometimes commission research on digital education to their universities or place digital education as a clear priority of their research agenda, it is striking that very few countries do actually monitor and evaluate investments in digital education tools and resources. Information about the physical infrastructure available in schools is missing, not to mention information about uses of digital technology, either as a management tool or as a teaching and learning tool.

Acknowledging that education and computer scientists, education technology companies and governments often work in silo, with relatively little involvement of the teaching profession in the definition and development of AI products, they should aim to establish multi-stakeholder co-creation models. One of the main purposes of this co-creation would be to develop digital technology tools and resources based on teachers and learners' needs and uses rather than on what is possible given a given state of technology. Some international examples of innovation laboratories based on different partnerships highlight some possible avenues to explore (chapter 13).

Support organisations

Almost half of the countries have published a new digital education strategy since 2020. Most have updated it during the COVID-19 pandemic. These strategies typically focus on the access to good hardware, the development of teacher and student digital competences, and more rarely the upgrading of digital learning resources with AI-based tools (chapter 14).

One of the challenges for governments in implementing their digital strategies lies in the difficulty of ensuring that staff have the digital competences to deal with the physical digital infrastructure, with digital tools and resources for management, the pedagogical knowledge regarding digital learning resources and tools, and the ability to support teachers in developing the pedagogical competences to embed the use of these tools and resources in their teaching repertoire. Countries have established different modes of support organisations to support the digitalisation of education. The analysis of the advantages and disadvantages of different models shows the benefits of these external organisations, even though in some countries driving the digital transformation from within the ministry of education might be the best solution (chapter 15).

Opportunities, guidelines and guardrails for an effective and equitable use of AI and digital technology in education

Based on some aspects of the analysis of the Digital Education Outlook, the report finally includes a set of "opportunities, guidelines and guardrails" that was developed by the OECD Secretariat and Education International. The guidelines were designed to provide a position paper that could inspire countries, organisations or jurisdictions in their digitalisation efforts. It proposes a starting point for further discussions and guidelines on these issues.

1 Towards a digital transformation of education: distance travelled and journey ahead

Stéphan Vincent-Lancrin, OECD

This chapter presents a vision of what a digital transformation of education could look like and what some of its benefits and challenges are. It argues that digital technology, including AI, could improve the effectiveness and quality of education by personalising education, be it teaching and learning or other education services, by making it more inclusive and possibly equitable, and by improving the cost-efficiency of the sector. A digital transformation of education also comes with risks that must be mitigated. The findings of the report about where countries stand suggest a few areas where they should focus their efforts to catalyse their ongoing journey of digitising the education operations towards a proper digital transformation. Taking advantage of the possibilities of widespread data collections and the use of advanced digital tools and resources to solve their educational problems will require further effort.

Introduction

Digitalisation opens new possibilities for education. While education has always been a sector rich in data, such as grades and administrative information, the use of data to help students learn better, help teachers teach better, and inform everyone's decision making in education systems – from parents and students through to administrators – is still nascent. Could digital technology, and, notably, smart technology based on artificial intelligence (AI), learning analytics, robotics, etc., transform education in the same ways it is transforming the rest of society? If so, what might this digital transformation look like and how can countries harness it?

This chapter starts by restating what current digital technology can do for education based on previous work on the trends and frontiers of educational technology (OECD, 2021[1]). The *OECD Digital Education Outlook 2021* highlighted different uses of digital tools and resources that had the potential to improve teaching and learning as well as the management of education institutions and systems. The COVID-19 pandemic accelerated the uptake and lived experience of digital technology for teaching and learning, but it also exposed the relative scarcity and basic nature of most digital resources and tools used in education (OECD, 2022[2]; Vincent-Lancrin, 2022[3]).

The *OECD Digital Education Outlook 2023* shows a similar picture, with a slow penetration of digital tools in education, but used mainly as a way to digitise existing educational processes. The visible emergence of generative AI has been a wake-up call for education policy makers: it has raised their awareness of the possibly disruptive nature of advanced technology but also of its imminent impact on our societies. While the frontiers outlined in the *OECD Digital Education Outlook 2021* may have appeared as distant, their time horizon is now perceived as very close. However, despite a chapter dedicated to generative AI (Vidal, Vincent-Lancrin and Yun, 2023[4]), most use of AI in education is not generative: when used, AI is embedded in systems that provide a diagnosis based on a large amount of data, that suggest decisions, or that capture learners' or teachers' information to provide them with feedback or suggestions. One of the big challenges for a digital transformation of education is for policy makers and teachers to have a better grasp of existing AI tools and resources specifically designed for education and to better use the data collected by a variety of digital systems to make education more effective and personalised for every student. A digital transformation of education could be about supporting students and teachers in their decisions based on observations that are not immediately accessible to them, and about designing policy reforms based on an unprecedented amount of (reusable and analysable) information.

The findings presented in this book are based on mixed method research: the OECD carried out a survey about countries' digital education infrastructure and governance, which was supplemented by a series of interviews and desk research. The comparative analysis in this book is based on the descriptive analysis of each country's digital education ecosystem and governance, which is presented in a companion report (OECD, 2023[5]). More details about each country's policies and practices are presented in this companion report. All the comparative analyses and data presented in these book, and notably its tables and examples, were double checked by countries in December 2023.

After recalling some of the opportunities and challenges of a digital transformation, the chapter will provide a quick overview of where countries are on this journey, arguing that most countries still face the challenge of shaping a digital education ecosystem that provides teachers and students with the appropriate tools to improve their teaching and learning, that can make the data collected by a variety of digital tools reusable to address important educational objectives, and that empower teachers and students in their educational career. Many building blocks are still missing for such an ecosystem to be effective: a stronger emphasis on teachers' professional learning, the availability and interoperability of some key digital tools, investment in hardware and connectivity where not of sufficient quality, and the establishment of new types of institutions that help to implement digital strategies – from "support organisations" to "innovation labs" that can create useful resources for education systems and negotiate their responsible use with all stakeholders.

Opportunities of a digital transformation

Personalising learning and education

The personalisation of education is one of the major potentials of digitalisation. Personalisation does not imply or assume that education is no longer social and collective; it simply refers to the delivery of education that helps learners individually in their educational journey. While the contexts can be different, the personalisation of education and learning is based on the same principles: capturing and detecting information that is specific to a student or that can be inferred from detections made on "similar" students; using the detected information to make a diagnosis, for example a recommendation; and in some cases, having an intervention based on this diagnosis, usually under the supervision of a human being (OECD, 2021[1]). This can be used for instructional decisions when giving study and careers advice, for designing specific educational interventions, etc. What the diagnosis phase requires is usually a large amount of data or observations that allows comparisons to be made between a specific person and others who share some of the same relevant characteristics.

Here are three examples of how digital tools (and notably AI-based tools) can support personalised learning or education.

In the classroom, AI applications that directly support student learning show early promise with the development of adaptive learning systems, including intelligent tutoring systems. Personalised learning aims to provide all students with the appropriate curriculum or task and scaffold them to solve specific problems based on a diagnosis of their knowledge and knowledge gaps. Increasingly, this personalisation of learning can rely on digital tools, which not only focus on "what" students should practice next, but also take into account how students learn and consider factors such as self-regulation, motivation, and effort (OECD, 2021[1]). These digital learning resources can be used and remain helpful outside the classroom too, for homework, as automated private tutoring or practice solutions, and for lifelong learning. While still too expensive to be present in education, social robots may perform similar tasks in different ways in the future: they can use adaptive learning to tutor students with natural language, but they can also teach or motivate them to learn by playing the role of a peer student (Belpaeme and Tanaka, 2021[6]).

While adaptive learning data are typically collected when learners interact with a specific software, AI in education can provide diagnosis information to teachers and school leaders about their students based on data collected for administrative purposes. Where countries collect standardised assessment data for each student over time, or just teacher-given grades, AI models can gradually infer a development or growth model for students' learning based on their "past trajectory" and a comparison with students sharing similar characteristics. This can give rise to a variety of recommendation tools. In many cases, the collected data is provided back to schools through dashboards so they can interpret it themselves and take action to improve students' performance (if needed). In a few cases, predictive models about individual students' "growth" can be designed, alerting teachers or educators when specific students do not follow the expected path. This may lead to different types of interventions. Early warning systems based on AI algorithms are based on the same model (Bowers, 2021[7]). Although they may use different types of data (e.g. absence patterns), they usually provide schools with an indication that a specific student is "at risk" of dropping out, notably identifying students that school staff do not necessarily suspect to be at risk. Here again, once the diagnosis is made, human beings have to intervene (or ignore the recommendation).

A third example relates to student's career planning and educational guidance. Given the complexity and variety of study paths (and possible careers), countries offer careers and study guidance services. They support students to navigate their education system and its different tracks (if any) but also help them to shape their expectations for a transition into the labour market. Some of these services are based on digital platforms with interactive services: they typically propose a personality test to identify students' tastes and preferences to propose a few possible related occupations and services. While this provides some level of customisation, one could imagine that some of this guidance could be personalised further using not only students' preferences but also their observed strengths and interests within the education system – thus providing more individualised advice.

These three cases present different modes of personalisation (or individualisation) of education but highlight how a digital transformation could make it possible. In all cases, this requires the collection of data not only about the individual about whom the advice is given, but a number of other subjects. This also requires being able to link data and build digital systems that can reuse relevant information for the mentioned purposes.

Inclusion and equity

The digitalisation of learning tools and resources can expand access to learning and teaching materials, and thus learning opportunities. Educational platforms proposing open educational resources or massive open online course (MOOC) platforms are good examples. At least in some parts of the world, they allow learners to access learning materials that may be superior to what they can access locally. When provided universally, closed-access resources limited to students enrolled in an education system can also provide students with more learning opportunities. Contrary to textbooks, digital resources can be made accessible at scale on a mere use basis. When provided by the national or central government, all students within the education system can access them and learn under the supervision of their teachers (but also possibly on their own). In the analogic world, this would be equivalent to providing students with all available textbooks and allowing them to choose the ones that work best for them, something that is not feasible under public resource constraints.

Some of the personalisation tools mentioned above can also have a positive impact on equality. Few studies show that adaptive technology (or personalised learning) reduces the achievement gap between students with more and less prior academic knowledge. For intelligent tutoring systems to reduce achievement gaps, they have to be more effective with students with more initial difficulties. Evaluated through a randomised control trial, an intervention in the US state of Maine showed that this may become the case (Murphy et al., 2020[8]; Roschelle et al., 2016[9]). Teachers in the intervention schools used an adaptive learning software to provide students with mathematics homework. The system provides feedback to students as they solve mathematics homework problems and automatically prepares reports for teachers about student performance on daily assignments. Teachers received training and coaching on formative assessment. The study found that students in the schools using the software learned more compared with their peers in the control schools, with large effect sizes, and that the impact was greater for students with lower prior mathematics achievement. A reduction of the achievement gap between different group of students is thus possible.

Just as important, digital technologies can reduce inequity by facilitating the inclusion of students with special needs and by adapting learning to different learning styles. Technology has, for example, made it much easier to support the diagnosis of learning difficulties such as dysgraphia, and remedial digital responses have also been developed. A variety of smart technologies applied to learning solutions also makes it easier for blind or visually impaired students as well as deaf or hard-of-hearing students to access learning materials and easily perform the educational tasks required from other students. AI-enabled speech to text (and vice versa) or automatic subtitles are the most obvious examples. Learning technologies also help address more difficult inclusion issues, for example by supporting the socio-emotional learning of autistic children (OECD, 2021[1]).

There are many other ways in which technology can support equity as well as the implementation of countries' policy efforts towards equity. While early warning systems give an example of AI-based recommendations to provide individualised educational services for those at risk of dropping out, many other individualised interventions can contribute to alleviating inequalities. Digitalisation makes it easier for countries and jurisdictions to individualise their services and target students with locally identified characteristics. In some countries, it has enabled shifts from school- or neighbourhood-based equity policies to individualised ones.

Enhancing the quality of teaching

As teaching is key to students' success, and as human educators are key to the wellbeing and holistic education of children in school, digital technology that supports and provides feedback to teachers and other educators offers another opportunity to improve the quality of education. The examples of personalised education presented above provide teachers with suggestions, recommendations and food for thought about specific students, unless the information is trivial. Perhaps this can make teachers realise that specific students needed more attention, or that they would have been expected to perform better (or not as well) as they do, or that they might be at risk of dropping out. This information derived from past data points that are usually not accessible to them, or from a comparison with other students within a system, enables teachers to reflect on their instruction practices and on how to customise them for a given student or class. In some cases, these digital tools not only provide information to teachers, but they also make suggestions on teaching and learning resources, etc. While teachers can ignore them, as is the case for medical doctors who receive information from their "expert systems", this can hopefully provide them with ideas to improve their teaching for a given context.

In the same way as digitalisation makes a wider array of digital learning resources available to students, it does so for teachers. Not only can teachers access open educational resources as well as multiple platforms of digital learning resources, they can also have dedicated platforms with digital teaching resources. The variety of resources can help them design their lesson plans, integrating digital elements into them, but also connect with their peer teachers teaching similar classes or subjects. Here again, the non-rival character and near-zero cost of reproduction of digital resources make it easier to provide teachers with more options to find their relevant teaching resources, made available by their government, their local authority, their school, or cultural agencies nationally and internationally.

Finally, while still work in progress and largely absent from OECD schools, classroom analytics may also support teachers to teach more effectively. Instead of taking students as the unit of analysis, classroom analytics focus on the entire classroom and provide teachers with real-time or post-hoc feedback on how to improve or "orchestrate" their teaching. Many applications already show how a variety of solutions could support teachers in better using their time in class, for example, by suggesting when it is a good time to shift to the next teaching or learning activity after students were given individual activities, identifying who would require their attention the most, and recommending how they could engage the whole class in collaborative learning activities. While some classroom orchestration solutions are designed to help teachers in real time, they also provide feedback on teachers' professional practice, measuring, for example, how much they talk (compared to their students) and to whom or how they divide their time between different types of activities (Dillenbourg, 2021[10]). Both real-time and post-hoc feedback are akin to personal professional learning opportunities for individual teachers in question, and they furthermore contribute to the personalisation agenda as their recommendations target the specific teacher who was (digitally) observed rather than a theoretical or general teaching practice. By providing individual teachers with reflective opportunities on their teaching practices and thus professional learning opportunities, digital technology could subsequently contribute to the wellbeing and learning outcomes of students.

Improving efficiency

In many business and government sectors, beyond effectiveness, a major rationale for digitalisation lies in efficiency. Many countries have embarked on digital government strategies to this effect, notably to make processes more efficient and easier for their users. The OECD has developed a Recommendation and principles highlighting these different objectives (OECD, 2020[11]).

There are different ways in which digital technology can increase cost efficiency in education. One example lies in student application (and admission) processes for educational institutions. Applications are sometimes undertaken through digital platforms, especially for the transition towards higher education, where a "matching" (or selection) process is often necessary. In open-admission institutions, when no selection is required beyond rule-based criteria, implementing seamless automated admission processes is even possible. The implementation of the National Education Information System (NEIS) in Korea, an e-government system that allows, among other things, for the digital transfer of students' academic records from one school to the other (as well as from school to university) was estimated to have saved USD 237 million a year when a cost-benefit analysis was undertaken in 2010.

A second area where digitalisation could lead to cost efficiency is the provision of verifiable degrees and other credentials, for example using blockchain technology (Smolenski, 2021[12]). The gradual development of an infrastructure for digital credentials and the adoption of open standards may lead to a different way of certifying and holding degrees, with individuals being able to manage their qualifications themselves.

A third area where cost efficiency is underway is the collection of system-level statistical information. While in the past statistical information often relied on the establishment of statistical panels (of representative samples of individuals or institutions) and often involved multiple handlings of the same data, the use of administrative data (when combined with the interoperability of diverse systems) has made it much easier to get statistical information from operational services in almost real time. Essentially, the latter avoids that administrators re-enter the same information several times.

But efficiency is also about how teachers use their time. Digital technology could help free some of teachers' time, allowing them to focus on the most stimulating aspects of their work. An obvious example is formative assessment, or developments in the automated grading of open-ended essays, because grading and designing assessments are time-intensive tasks when done manually. Another example lies in some of the administrative tasks that teachers have to perform that could be supported by computers. By freeing up time for teachers, smart technologies can allow them to dedicate more time to learners who most need their attention, and to focus on their own continuous professional development or on supporting complex aspects of students' learning, including the acquisition of higher-order or of socio-emotional skills.

Enhancing research and innovation

Digitalisation helps to promote another aspect of efficiency and effectiveness: improving policy design and reform based on evidence, research and quick innovation (OECD, 2019[13]). In a digitalised education sector, the unprecedented amount of collected data allows researchers and governments to undertake research on their education systems in order to reform it and achieve their goals.

While digital tools have a practical utility, their development also helps to uncover educational patterns that were not previously visible. They help to better understand education systems, their actors' behaviours, and thus to design better policies and better practical interventions. For example, the research on early warning systems has not only led to predictive tools, it has also enabled researchers to recognise that different profiles of students were at risk of dropping out and that the types of interventions they required were thus different. Bowers and Sprott (2012[14]) showed that the majority of high school dropouts did not match common wisdom about dropout and these students were thus likely "invisible" to many education stakeholders. This is one example among many showing the value of collecting and analysing robust data and having a strong data infrastructure for better policy design.

Making education more relevant to modern times

Regardless of the benefits of personalisation and cost-efficiency, a strong argument for the more intensive use of digital tools and resources in education lies in the development of learners' digital skills. This is one of countries' main educational objectives, recognising that education should reflect and prepare students for modern societies. While in the past, most evaluations of digital technology in education focused almost exclusively on their effects on students' learning outcomes, usually in mathematics or language, both the COVID-19 pandemic and the ongoing digital transformation of our societies have shown that this may not be the only rationale for digital education. Even if the use of digital technology did not improve the effectiveness of education compared to its non-digital equivalent, it might still be important to use digital tools to develop students' digital competences: to ensure a better mastery of digital technology, to familiarise them with it, and to help them understand broadly how it works. Many countries have made "digital competences", defined in different ways, a transversal competence (and made "computer science and/or computational thinking" a more important part of their curriculum).

Generative AI is an interesting point in case. While its emergence was considered as disruptive by many and framed in terms of "cheating", it may be an opportunity to prepare students for the modern age. Assuming that in the near future generative AI becomes more prevalent in the labour market and our lives, getting students used to working with it, getting skilled at preparing prompts, knowing what to (and what not to) expect from it, are all just another dimension of developing their digital competences. Moreover, as a productivity tool, it can allow teachers and students to do much more than what would have been possible before: produce more text, create and refine images that would have been very time consuming to produce, get help in producing music and songs, etc.

Challenges of a digital transformation

Opportunities usually come with challenges and unknowns, especially when digital technology is new and evolving at a fast pace. Harnessing the promises of a digital transformation requires both awareness and mitigation of those risks, and a careful cost-benefit analysis. While some of the risks are new and specific to digitalisation, many are not; digital risks need to be compared with the risks of a non-digital education.

Digital divides

Despite the possible benefits of digital tools for equity, the COVID-19 pandemic has exposed inequalities of access to connectivity and digital tools within education systems, and notably the inequalities of access to digital devices and connectivity (Thorn and Vincent-Lancrin, 2021[15]; Vincent-Lancrin, 2022[3]). As long as access to high quality connectivity and to sufficiently recent digital devices is not universal, digitalisation will present challenges to equality of opportunities and equity. As noted by Fragoso (2023[16]), the availability of appropriate hardware is a necessary condition for a digital transformation of education, one that most countries are aware of and upon which they focus their investments and digital strategies. Remote learning during the pandemic highlighted that school education did not stop at the school doors but continued at home. A lack of available devices and connectivity at home is a problem for digital education. Providing quick and affordable broadband or mobile data connectivity across a country is usually not in the ministry of education's portfolio. Many countries had interesting initiatives during the COVID-19 crisis to create a more even playing field: most of those initiatives, such as making education platforms free of charge to end users, have since been discontinued. Interesting initiatives to alleviate discrepancies in access to digital devices and connectivity continue though, as is the case in Japan, Luxembourg or the Flemish Community of Belgium for devices, and the United States for connectivity (OECD, 2023[5]).

A second challenge of digitalisation lies in the availability of advanced technology within countries. Even though they can be considered as more or less centralised, all countries have decentralised education systems. The devolution of responsibility takes different shapes and forms across countries, but regional governments, local governments and schools themselves play a role in choosing digital tools and resources. In addition, depending on the school funding formula, public schools located in different parts of a country may have budgets that are significantly different and allow for a very different provision of digital tools and resources to students and teachers. It is, for example, possible that local education authorities in richer neighbourhoods provide their schools and students with more and better AI-based tools (e.g. intelligent tutoring systems) and that this increases the achievement gap and inequality of opportunities with students (and teachers) in poorer neighbourhoods and schools. The variation in the cost of (and budget spent on) textbooks and other paper learning resources across schools is likely to be smaller. Depending on the effectiveness of digital learning tools compared to textbooks and static learning resources, digitalisation may lead to more inequalities unless governments address the issue and ensure that there is at least a minimum basis of digital tools and resources available to all schools in their territory (as is for example the case in France, see (OECD, 2023[5])).

A third challenge that may correlate with the previous one comes from the inequality in the digital competences of teachers within countries. Even though the COVID-19 pandemic led to a forced use of digital tools in education and has made teachers more familiar with digital teaching and learning resources and tools, there are still widespread variations in teachers' confidence and interest in integrating digital resources in their teaching. Where those resources are not available, lower competences can come from the lack of opportunities to develop them.

The jury is still out on whether digitalisation is likely to widen or help close the gap between educational outcomes in high- and low-income countries (or high- and low-income regions within countries). On the one hand, digitalisation requires continuous investments in hardware (connectivity and devices), for which access is still a limitation in many countries. It also requires digital teaching and learning tools and resources that are adapted to local contexts and thus a certain level of available expertise within countries. On the other hand, digitalisation makes knowledge available in countries where people struggled to access recent knowledge, and light models of generative AI that run on a mobile phone with low bandwidth requirements may support teachers and learners around the world, regardless of their country's income level. Some middle-income countries/jurisdictions have shown that digitalisation could be used to improve system performance without introducing advanced technology products or services in the classroom. Digitalisation is an incremental process, and all countries can reap some of its benefits by clearly identifying the purpose and means of using digitalisation to solve a problem. In Gujarat (India), for example, where absenteeism of both students and teachers was a problem, the digital monitoring of school attendance coupled with the provision of dedicated human resources and services have led to a significant reduction of the problem (Vincent-Lancrin and González-Sancho, 2023[17]).

Performance of digital tools

While digital tools hold many promises for more effective education, they do not have perfect performance yet – contrary to calculators, for example. It is possible that some of the most advanced tools will always have their shortcomings, as is the case for human individual and collective intelligence. As they may make mistakes in the advice or recommendations they provide to students, teachers, parents, etc., it is important to understand their limitations and that they are used under the supervision of competent human beings.

For example, while some early warning systems now approach very good predictive power, Bowers (2021[7]) shows that a significant number of them rely on predictors that are no better than a random guess. In the areas of student engagement, D'Mello (2021[18]) points to new approaches that are developed to better measure students' engagement in learning using facial image analysis and other ways but also notes the inaccuracy of many of the measures used in the field of learning engagement. In the area of classroom analytics, Dillenbourg (2021[10]) notes that some solutions manage to identify whether learners are working individually or in groups with a very high level of accuracy (90%) but identifying the type of teaching and learning activity remains more challenging (67% of accuracy). Those are just three examples, showing that accuracy levels can be very high, but are not guaranteed for any AI-powered education application. Despite their impressive natural language generative power, AI text generators also have “hallucinations” and provide erroneous information with perfect syntax.

Most of the time, these shortcomings do not matter because the stakes are low: AI systems make recommendations that may be more or less correct but are checked and can be discarded by a human being. Human beings also make mistakes and give advice that is not worth following. While AI-based digital tools should be able to demonstrate a certain level of performance to be put on the market, some level of mistake is not necessarily a serious problem as long as those have no serious consequences for the users. We are used to all sorts of errors, made by machines and humans.

For example, an early warning system that makes good predictions 7 or 8 times out of 10 would actually be very useful – assuming it makes visible those signs or patterns of dropout that are not so visible to teachers and school leaders. In the 2 to 3 cases when such a system is wrong, human educators may realise this is a false alert not to be followed and hopefully the interventions put into place will not be harmful to students that are not really at risk. The cost of those mistakes (in terms of inefficiency and annoyance for “false positive” cases) should be compared to the benefits of the system (compared to a uniquely human detection of potential dropout cases).

However, when a system has high stakes for individuals, our tolerance for errors should be minimal, and the systems we use should have perfect or very high levels of performance. For example, if early warning systems were not meant to provide support to students to prevent a bad outcome to happen, but led to an intervention that would be extremely costly and risky for students, it would be unethical to rely on a digital tool with imperfect performance (even if humans were also making imperfect decisions).

New or amplified biases

Some AI-based digital tools have been shown to perform better for some population groups than for others. For example, an intelligent tutoring system that is used universally could work better for, say, girls than boys. Depending on the initial situation, it may actually increase or decrease achievement gaps between girls and boys. A speech to text software may work much better for white than for black English speakers, making only one share of the population able to reap its benefits. While these issues are also a “performance” problem, they relate to equity and are not easily identifiable based on the overall performance of a digital tool or resource: an AI tool may have a good performance for the entire population, but work badly for some minority groups and put them at a serious disadvantage.

Some digital tools are designed to work better for certain groups of the population, as is for example the case with assistive technologies for students with disability or with special needs. The idea is thus not that all digital tools should always perform the same for everyone. The real problem arises when they unintentionally advantage some groups compared to others and amplify rather than reduce societal biases such as racism, sexism, anti-migrant biases, etc. While human beings have prejudices and are the origin of societal biases, machines built on these biases will replicate them in a systematic, automated way that could amplify their effects compared to human bias.

Some cases of algorithmic bias with extreme consequences were highlighted in (mainly) other sectors than education (e.g. finance, justice) (O’Neil, 2016[19]). While education does not use much automated advice to make final decisions, Baker (2023[20]) shows that educational tools have also been shown to have unintentional differing performance for diverse groups. Should it happen for decisions that matter for eligibility to certain support services, admissions to schools or universities, or disciplinary sanctions, this would be extremely problematic. This is certainly a new challenge and presents upcoming risks that countries will have to address.

Inefficiencies of a digital ecosystem

The past introduction of digital tools in education, notably computers, has led to cost-inefficiencies – simply because the computers were not used. Instances of a lack of use and a lack of usefulness of education technology have given rise to repeated critiques of education technology (Cuban, 1986[21]; Reich, 2020[22]). Many education officials perceive the COVID-19 pandemic as a wakeup call for education staff that were not always using or aware of what governments provided. At the same time, the increased use of technology in classroom instruction represents one of the biggest changes in classrooms of the 2010s (Vincent-Lancrin et al., 2019[23]), which was accelerated by the remote learning and alternate modes of schooling during the pandemic. Sometimes the lack of use can be ascribed to the quality of the digital education tools that are proposed. Education technology is sometimes designed and proposed because it is technologically possible rather than because it is useful and provides clear benefits to end users in education. Most education technology products are mere educational derivatives of solutions designed for other sectors. Even when technology applications are useful and beneficial, some teachers, learners and users may have no interest in using them. There is thus a risk that digital teaching and learning resources are available and publicly provided, but that they are not used by education stakeholders, therefore increasing costs without changing outcomes.

Another possible source of cost-inefficiencies lies in the fragmentation of the digital education ecosystem, which is always comprised of a variety of digital tools and resources. If not properly managed, this diversity may lead to an increased workload for teachers and administrators, with multiple data entries of similar information in different software. As we will see below, efforts towards interoperability can help address such sources of cost-inefficiencies.

Privacy and data protection

Digitalisation raises new issues (and costs) related to privacy and data protection. It also raises new possibilities that expose children to access inappropriate interactions or content. New privacy challenges emerge as an increasing amount of data are collected, especially when they can be linked. The challenge is exacerbated as most people post personal information about themselves on the Internet, making it easier to reidentify them from a pseudonymised dataset. As technology and service providers collect and manage increasing amounts of information on behalf of schools and education agencies, more and more data shift outside the direct stewardship of education agencies, feeding concerns that personal information about students or teachers could be used inappropriately or lead to privacy breaches. Harm arising from a privacy breach can affect individuals or communities, may be objective or subjective, and can involve economic, legal, psycho-emotional or reputational injuries. Privacy and data protection has become a major focus of digital education governance, as discussed in the next section of this chapter.

Ethics of AI

The ethics of AI in education (and elsewhere) has become a major policy concern. Ethics only really matters when there is no regulation. For any serious issue, regulation should trump the ethical behaviour of stakeholders. Over-regulating is a risk, especially for evolving and not well-known technology, but leaving decisions that could lead to serious harm to the ethics of individuals would be unreasonable.

There are two types of ethical problems raised by digitalisation. One type is about what algorithms are allowed to do. For example, where people feel discomfort in the monitoring of students' emotional states, directly or indirectly, even if it would help to identify and address cyberbullying or support their learning, regulation is the right option. Regulation should not inhibit finding weaker ways to balance the costs and benefits, for example by mandating data deletion immediately after processing, which would avoid keeping records of emotional states while reaping the benefits of monitoring (assuming it is accurate and contributes to protecting children or improving their learning performance). Recently published guidelines and forthcoming regulation (in the European Union) address this issue by recommending or planning to limit the uses of AI technology.

A second type (enabled by the first) is about the use of AI by human beings. For example, if the identification of students at risk of dropping out from high school leads to their stigmatisation or to their expulsion from school, for example as a way for school leaders to preserve their school's graduation rates, this would be an unethical use of digital tools as it would harm the students that the algorithm identified as requiring support. If classroom analytics designed to support teachers to improve their teaching practice could be used against them as a "performance assessment" tool, this would also be problematic ethically. The ethical challenge in these cases does not stem from the technology affordances, but from how human beings use them. Guardrails about how AI and other advanced technology should be used by humans is thus crucial to enable its beneficial uses.

Last but not least, many observers and stakeholders worry about digitalisation implying an overhaul of non-digital forms of learning. Concerns used to be expressed as excessive "screen time", but as digital technology also involves so many other non-screen activities, the question is more about digital technology time. As education is and will remain a portfolio of very diverse educational activities, it is difficult to imagine an education that would be only digital and that would not allow students to develop perception and knowledge through the direct experience and use of their five human senses. A digital transformation of education does not imply that all educational activities would become digital, as the opponents of digitalisation sometimes claim. It is difficult to pre-define how much digital devices should support education, but for sure formal education should have students maintain an ongoing engagement with their peers, local communities and the natural world, without the mediation of technology. Framing the problem as a choice between two exclusive options is unhelpful.

Social acceptance

Challenges for a digital transformation of education are partly technical, as mentioned above. However, probably the main overarching challenge is societal. Education policy makers, teachers, parents, and even students, are used to an education standard with very little to no technology. One implication of a digital transformation is that some current practices, which have sometimes taken several decades to become accepted as a fair and normal practice, will be challenged.

An example lies in adaptive assessment. In some countries, parents, teachers and their representative organisations, as well as students, pushed back against the introduction of adaptive assessments. As an analogy, ophthalmologists diagnose which glasses people should wear with adaptive assessments: with the support of their machine, they ask a series of questions to fine tune their diagnosis and (hopefully) provide the right prescription for lenses. Not every patient gets the same questions as it depends on what and when you start seeing things, seeing them blurry, etc. Adaptive assessments do more or less the same with mathematics or reading: they try to provide more fine-tuned assessments by providing questions and exercises that get closer to what students know and understand. As the current standard for a fair assessment is that all students take and are assessed on the same questions, adaptive assessments were considered unfair by society.

While opposition to any use of technology in education (while it is widely accepted in other sectors such as the health sector) should be challenged, naïve endorsement of technology should also be questioned. While digital technology presents many opportunities for the advancement of educational goals, it is neither a panacea nor a poison. Significant challenges for governments lie in transparency about its uses; co-creation and negotiation of its uses; and communication about its benefits and how its potential pitfalls are addressed.

Digital education ecosystems: where do we stand and what more could be done?

Given the opportunities and challenges laid out before, governments and other stakeholders willing to foster the digitalisation of their education systems have several tasks at hand. The first is to improve their current digital education ecosystem. This section provides a brief overview of the findings presented in the book. The next section will consider the second task of governing digital education to address the challenges and enabling the benefits of a digital transformation of education.

Digital education ecosystems are hybrid human-technology systems. They consist of a mix of human competences, hardware and connectivity, and two types of software: digital tools for system and institutional management, and digital resources for teaching, learning and assessing in the classroom. The pandemic raised a big question: what is the minimal infrastructure a country should provide to its schools, teachers, and students for learning to continue in case of a disruption, but also generally speaking? Another observation it made visible is the gap between what would be possible to make education more effective and equitable if teachers and students were augmented by digital education tools, including AI tools, and what countries, educational authorities or schools currently provide.

Having a robust physical digital infrastructure is a pre-requisite for digital education. High quality connectivity and enough quality devices for students and teachers are a moving target that requires continuous investment. Improving the quality of connectivity in school and in their country as well as the availability of digital devices is a priority for many OECD countries (Fragoso, 2023[16]). While these efforts are essential, just providing digital devices and good connectivity will not lead to a digital transformation of education.

Assuming countries' digital hardware is of good quality, policy makers should consider two big questions:

1. what are the digital tools and resources that could support effective teaching and learning in the classroom and help achieve some of their educational goals (such as making education more inclusive and equitable, making teaching a more attractive profession, providing a holistic education, etc.)?
2. starting from their policy objectives, what digital education ecosystem should they try to build and, in particular, how can they reuse and share collected data so that it helps achieve these policy goals?

In short, the digital ecosystems of educational tools and resources as well as the availability and use of the overall data infrastructure within their education system should be a main concern. Should they not have quality hardware, they should work on improving it and, in the meantime, analyse how they can use the current infrastructure despite its shortcomings.

Let us imagine a country that would want to reduce high school dropout. They could communicate this policy objective and let education practitioners address it without any technology. Using technology and data collected through their digital infrastructure, they could think of different ways to support those education practitioners (who would still have to act at the end of the day). A first way is to create digital tools with reporting systems for absences that trigger a human intervention (e.g. some people go to their home to see if they can reengage the students). This is a reactive approach in which technology enables a faster response than before. Another, more proactive approach is to try to detect the possibility of drop out before it happens (and intervene pre-emptively). This is what early warning systems try to do. What does it take to do so? Typically, countries need to have data about students who dropped out in the past as well as data about their current students – and based on what they collect, they have to figure out how to design strong early warning indicators and then make the relevant data available to teachers and school leaders in real time. A possible challenge in that scenario is that the relevant data to anticipate a dropout risk may be held in different digital systems (e.g. attendance and teacher-given grades in the school system, standardised scores in the national evaluation system, and information about the school or family characteristics in the jurisdictional information system), so that "early warning" is only possible if the relevant data can be accessed, linked, and brought back in a timely manner to the relevant stakeholders dealing with the students at risk of dropping out. A third approach, which can (and often has to) supplement the two first ones is to commission research using the data collected about dropout to better understand who drops out and under what circumstances. While this helps improve policies and better understand the phenomenon, this typically does not help an individual student in real time.

An important message of this hypothetical story is that administrative systems can serve other educational purposes than the administrative processes for which they were designed if the data they collect are used for these other purposes – and if the human policies to reach these benefits are developed (OECD, 2023[24]).

System- and school- level digital management tools

This book provides a comprehensive overview of countries' digital infrastructure to manage schools and education systems.

The cornerstone of a digital education infrastructure at the system level lies in a longitudinal student information system. Student information systems collect information about the trajectory of each individual student in the system and thus provide the possibility to make the entire education system benefit from information that is gathered at the national/jurisdictional level. This is an important digital tool to turn data into actionable information for local stakeholders in real time. As of 2024, most OECD countries have established a longitudinal student information system, but they still use it mainly for statistical purposes rather than as a way to provide real-time information to stakeholders. A second best is to have a central student register with unique longitudinal identifiers for students (and possibly teachers). The information gathered will allow for generating research evidence that may inform education policies within countries – but cannot quickly be turned into action for individual students (Vincent-Lancrin and González-Sancho, 2023[17]).

Current longitudinal information systems can be described according to four ideal types:

- *The reporting and research approach*. The longitudinal data has allowed countries to enrich their performance cards, but the data and reports produced mainly seek to support policy planning and to inform the public. In some cases, data systems also intend to develop research capacity about educational issues. Most student information systems not only fulfil this function but are also limited to it.
- *The e-government approach*. These student information systems were designed to improve the efficiency of administrative processes (e.g. school transfer, school choice, university application, funds allocation to schools). They contain more data and linkage possibilities than other models, but have a weaker focus on functionalities aimed at improving teaching and personalising education and on reporting learning data to teachers.
- *The school improvement approach*. Putting school improvement at the core of their mission, they can be close to information systems in the reporting and research approach, but typically report data to schools, generally with a visualisation tool. They try to provide information at the individual level and with a granularity that makes it useable by teachers (for example, item-level reporting of assessments).
- *The expert system approach*. Inspired by "expert systems" supporting decision-making, they typically provide rapid and granular feedback to teachers, students and principals, as well as support materials to enhance learning. Beyond mere reporting, they have predictive models and make recommendations, which may be followed or not.

While student information systems are probably where to start for countries establishing a digital education infrastructure, as the digital ecosystem matures, they may become one of its components and may not have to play a central role. While countries should try to move from a mere “reporting and research” to an “expert approach”, this may not have to be a characteristic of their student information system but rather of their entire digital education ecosystem. All depends on the possibility to share and exchange data between the digital tools within the ecosystem (interoperability). Having a robust system-level student information system enables the possibility to receive and send back system-level information to stakeholders (as appropriate, given certain objectives) – this can also be done in different ways, but with usually less ease, which is why it is initially the most importance piece of a system-wide digital education ecosystem.

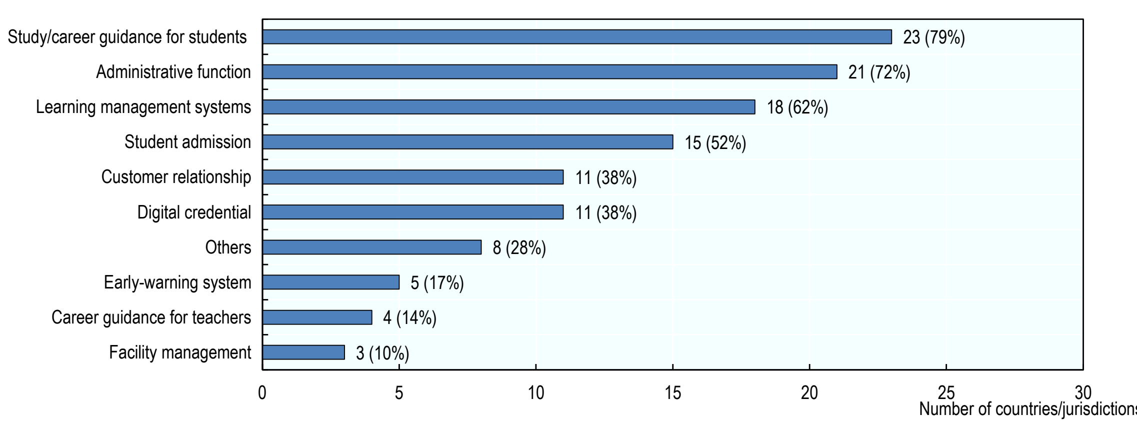
Countries’ digital education ecosystem is comprised of many other system- and institution-level digital management tools. Learning management systems are the equivalent of student information systems at the school/institution level: they allow schools to manage and track information about individual students, which classes they attend, with which teachers, and, in some cases, to access digital content for teaching/learning. Ideally, learning management systems should be able to “push” and “receive” data to and from their jurisdictional student information system. While most countries report that most of their schools use such learning management systems, at least at some educational level, about half of them are not interoperable with system-level student information systems and require schools to manually provide information to their public authorities/ministries, and in turn are unable to receive any insight from the data collected at the jurisdictional level (Vincent-Lancrin, 2023[25]).

The report shows that most countries provide study/career guidance information through digital means, even though few of them provide tools for more personalised enquiries, and that most national evaluations are digitised or in the process of being so. Digitising actual high-stakes exams for students is a different story, and while some OECD countries are exploring this path, only a few of them have done it (Finland is an example). A few countries have digitised some aspects of the administration of their paper-and-pencil exams as well as their selective admission processes into higher education (and sometimes high school) (Vidal, 2023[26]).

Figure 1.1. provides a picture of the public provision (and use) of digital system- and institution-management level tools.

Figure 1.1. Public provision of digital education management tools (2024)

Number of countries who publicly provide the following system- and institution-level management tools at national or sub-governmental levels



Note: N=29. 19 countries/jurisdictions have a central longitudinal student information system, while 3 additional countries have all or most of their sub-governments providing ones. Institution-level management systems are typically provided at sub-governmental level, e.g., states, regions, school districts and municipalities. See chapters 2 and 3 for more detailed information.

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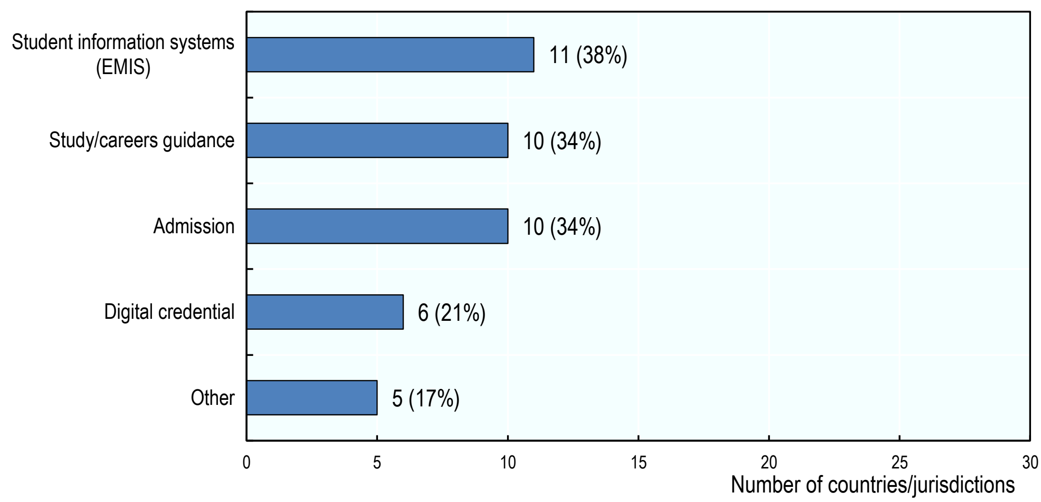
Despite ongoing discussions about AI in education, it is noteworthy that relatively few system- and institution-management digital tools use any AI technology such as learning analytics or recommendation tools. The most advanced uses of technology consist of making information available through dashboards or of implementing rule-based algorithms, notably for funding mechanisms or for managing enrolments in or applications for schools.

Figure 1.2. System-level management tools with automated rule-based displays or algorithms (2024)

Number of countries/jurisdictions who publicly provide digital systems with dashboards or some level of rule-based automated recommendations



Note: N=29.

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Figure 1.2 shows that in education it is relatively infrequent for digital tools to use even non-AI based algorithms, such as dashboards, or rule-based decision-making or adaptive models. Almost no country reported the use of AI techniques for system-level tools or a common use of them for institution-level tools. There is virtually no "automated" decision- or suggestion-making in education. For example, while most countries have digitised their national standardised evaluations, if not their examinations, almost none use the digital affordances of computer-based testing (such as the use of videos, simulations or adaptive testing). While most countries provide study and career guidance platforms for students, those have relatively little adaptive functionalities that would allow to individualise the study or career suggestions.

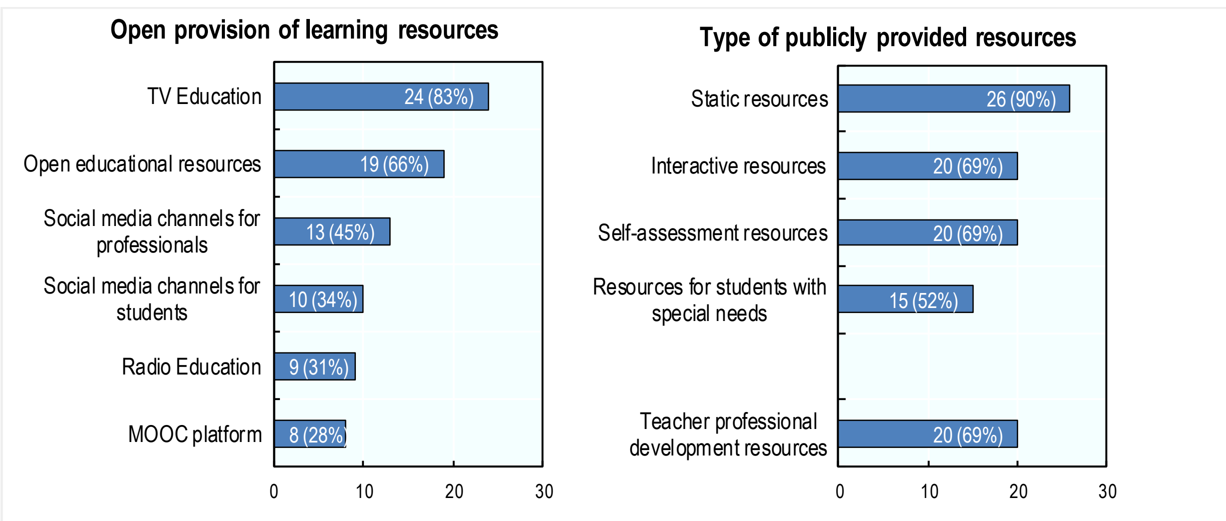
Digital ecosystems for teaching and learning

A second question is about the digital learning resources that are accessible by teachers and students. This is another issue that the pandemic has made salient and that led to many new promising initiatives within countries. What is the minimum level of digital learning resources that should be available to any student (and teacher) in an education system? Given the new possibilities of digital education, what are the next-generation digital learning resources that would help students succeed?

Let us think again of a country where preventing school dropout is a priority. Beyond the use of data collected at the system level to power early warning systems and trigger interventions, there could be many instructional ways to keep students engaged in school. Some countries and jurisdictions may be tempted to invest in tools that will help students succeed and ensure they can continue to learn or practice while they are out of school. This could be adaptive learning systems for example. They could also be interested in software that help students remain engaged in their learning. They could provide a variety of resources that will help students find what they are interested in and support teachers in developing their students' skills in this area, even if not in mathematics and literacy. They could provide teachers with resources to better understand what is of interest to their students, to design more easily engaging lesson plans, etc. All this would assume that an engaging education in subjects of interest to the students would help keep them in school, especially if they are supported and successful. This is already what teachers do, but digital tools can help them to diversify and individualise their teaching. A country making this assumption may want to have a digital ecosystem with some of the teaching and learning tools and resources mentioned above.

As shown by Figure 1.3, most countries are now involved in the provision of digital teaching and learning resources for both students and teachers (Yu, Vidal and Vincent-Lancrin, 2023[27]).

Figure 1.3. Public provision of open and closed access teaching and learning resources (2024)



Note: N=29.

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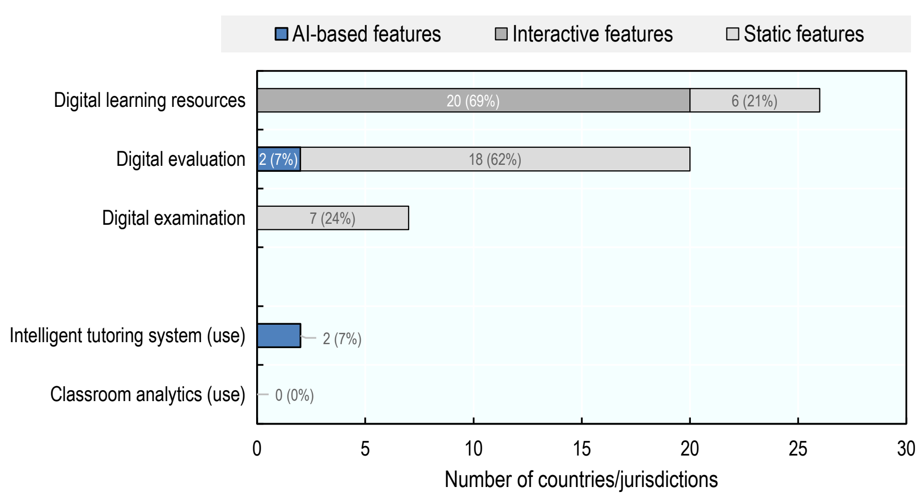
The OECD, alongside other international organisations such as UNESCO, have long encouraged countries to develop platforms of open educational resources (OERs). OERs have the advantage of being available free of charge to everyone and thus can support not only students and teachers, but also the general public and lifelong learning. MOOC (massive open online courses) platforms have also expanded that offer, as is the case for TV and radio education and social network channels in selected countries. Most of these offers were boosted by the COVID-19 pandemic and remain available in some countries. Some of these resources are mapped against the national or jurisdictional curriculum. While open educational resources are important, notably to provide an equal baseline to all, the risk is that they get outdated if not continuously updated and modernised. When curated by governmental authorities, one can expect them to be of good quality. In many countries, governmental platforms are supplemented by non-governmental OERs developed by teachers, non-governmental organisations, universities, etc.

Another way for countries to support teachers and students is to license digital learning and teaching resources from commercial education publishers or to enable municipalities or to procure their digital learning resources from them with their public budget. In this case the digital learning resources and tools are provided on a closed access basis, that is, only students and teachers with a recognised role in the education system will be able to access them.

The advantage of a central provision is that central governments have in principle more capacity to quality assure resources and that the resources will be available for teachers and students in the entire education system, regardless of the preferences of their school leaders or choices of subgovernments. Where there is a very uneven provision of digital learning resources and tools, this can be an effective way to level out the playing field. The possible disadvantage of a central provision is that the resources are provided and not used. Schools or local governments may be better placed to choose what suits their students. In any event, while having a baseline of "free of charge" or open resources is important to allow all citizens to benefit from public education, private providers remain overall better placed to keep learning resources up do date and should certainly remain part of the public provision/procurement equation.

As of 2024, the majority of digital learning and teaching resources provided by public authorities and used in the classroom remain static, such as (non-interactive) digital textbooks, video content, and past exam questions, which may often merely transpose conventional chalk-and-board teaching methods to a digital format. Static digital resources are useful and will always keep a role in the education process, as is the case for physical, non-digital resources. However, the lack of engagement with AI-based digital learning resources may be a missed opportunity to provide more individualised teaching and learning. Most digital learning resources provided and used in OECD schools are non-adaptive. Interactive digital textbooks are the most widely used "advanced" digital learning resources: they are more interactive and include exercises related to the lessons, etc., but they are still typically not adaptive. Intelligent tutoring systems, which could allow students to overcome some of their misconceptions and master procedural knowledge, are still rarely available and used within countries – not to mention other types of smart technology (OECD, 2021[1]). Most AI in education seems to mainly consist of the use of generative AI, a general purpose AI that is used in practice in all countries and jurisdictions, even if not in the classroom.

Figure 1.4. A limited provision or use of digital tools and resources with interactive or AI-based features (2024)



Note: N=29.

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How do these digital teaching and learning resources fit in an effective digital ecosystem? Each of these digital tools and resources have a value and function for teaching and learning, and fragmentation is not necessarily an issue. It is easier for students and teachers to access those tools and resources without multiplying their access to different platforms, so that being accessible from their school learning management system is an advantage. This is not always possible as students and teachers may have to access them through the platform of a commercial provider (when not provided directly by a public authority). An increasing number of countries offer “single sign-on” solutions to avoid that students manage several access codes (and to protect the privacy of students from the vendors).

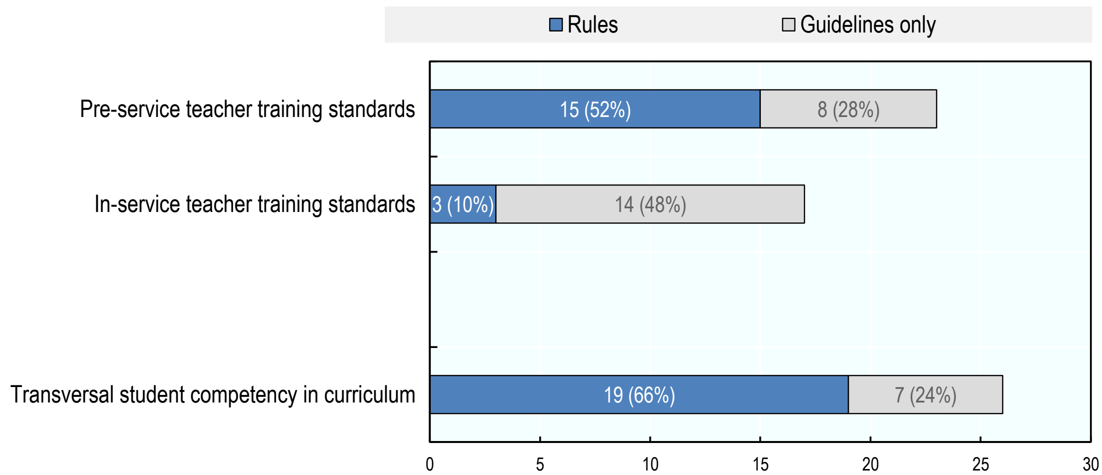
As the most advanced digital teaching and learning tools typically collect information about their use by students (and teachers), one could imagine that at least some of the data they collect with public funding and often in public schools could be reused and connected to the overall education data ecosystem. It is also possible that the data collected by one digital learning tool could have value for another tool, which would make it valuable for them to be able to exchange information. In what cases this could be useful and how this could be achieved still need to be imagined.

Digital competences

As mentioned above, a strong digital education ecosystem is a hybrid human-machine system and encompasses students and teachers who are able to use the digital tools and resources at their disposal, provide feedback for their further improvement or competently enforce digitalisation-related regulation. This is also true for school leaders and education administrators as system- and institution-management digital tools get increasingly used. There is no point in providing digital resources that are not effectively used by teachers and students, who should be considered as an integral part of a digital education ecosystem. It is noteworthy that digital competences are just partly about having the skills to use digital devices or find digital resources. These technological competences are important, but digital competences mainly refer to the ability of teachers to use digital tools and resources in their teaching, including advanced technology such as AI. Many countries increasingly emphasise “AI literacy” as an objective for teacher professional learning, which includes both the understanding of the basic functioning of AI models and tools and the use of AI tools (such as specialised educational AI tools or general-purpose tools such as textual or pictural generative AI).

Countries incentivise teachers to develop their pedagogical digital competences in different ways. Most countries (24 out of 29) have some national rules or guidelines on teacher digital competences, but significant differences exist across countries: 14 countries have rules about pre-service teachers compared to only 3 countries for in-service teachers (the latter are more likely to be devolved to lower levels of government). Most of the rules for pre-service teachers are standards that guide teacher training programmes in designing their programmes: their enforcement may be checked when accrediting or recognising those programmes or, more rarely, tested or verified as part of teacher certification/licensing or hiring. Those pre-service standards are often seen as guidelines for in-service teachers, meant to indicate where to put their professional development efforts. As mentioned above, many countries do provide their teachers with digital learning and teaching resources that also encompass the use of digital tools and resources as part of teaching. In general, such rules and guidelines remain high level and as few countries proactively enforce standards by evaluating teachers’ digital competences or linking accreditation processes to the development of digital competences, one may wonder how effective they actually are.

Figure 1.5. Rules and incentives for teachers' digital competence development (2024)



Note: N=29. In 15 countries out of 29, there are regulatory requirements about digital competences to enter the teaching profession, and in 3 countries to maintain those competences while in service. In 19 countries, teachers are incentivised to develop their digital competences by the integration of digital competences as a transversal competence in the student curriculum.

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Almost all countries have national rules and guidelines on developing student digital competences. In most cases, these refer to all educational levels (or all levels excluding VET) and these are often integrated across the curriculum. Expecting students to develop digital competences as part of their mandatory education and across all subjects implies being taught by teachers with their own digital competences. However, very few countries formally assess student digital competences, so the incentive structure is also weak.

Countries and jurisdictions could consider different ways to provide stronger incentives for teachers to develop and maintain their digital competences. They could formally assess teacher digital competences, for example as part of teacher qualification processes (e.g. through examinations), as part of teacher trainee evaluations, as part of compulsory or voluntary certification processes, or by strengthening their relevance as part of internal teacher appraisal or external school evaluation criteria.

Where not already the case, countries could link their teacher digital competence expectations to concrete accreditation processes of higher education teacher training programmes (that could also include criteria on the assessment of digital skills). This could help to ensure relevant content in initial teacher education and promote equal opportunities for student teachers to develop their digital competences, while still affording higher education institutions (and other teacher training institutions) with flexibility and autonomy.

Building strong incentive structures to encourage participation in relevant professional development activities as part of career advancement paths can be a powerful way to encourage teachers to maintain and (further) develop their digital competences. These might include new reward and mobility structures within the teaching profession that reflect digital skills, including both vertical (i.e. promotion) and horizontal pathways (e.g. specialised digital roles that come with recognised concessions in teaching responsibilities). Formally recognising digital skills development, for example through certification or micro-credentials, can also incentivise professional development for motivated teachers, although such incentives are unlikely to be effective unless paired with some formal exemption or fulfilment of professional development obligations that matter for career progression and/or compensation (Foster, 2023[28]).

Governing the digital transformation in education

Developing a governance of digitalisation to shape an effective and equitable digital transformation requires focusing both on how to enable the digital transformation and on how to mitigate its risks and challenges. Innovation or digitalisation is not an end in itself. It has to be a means to achieve specific educational objectives: personalisation, inclusion of students with disability or special needs, social diversity in school, etc. The first important step is for countries to identify those purposes and how digital technology as well as a robust data infrastructure could help achieve them, if possible. While most (23 out of 29) countries have published a new or updated a former digital education strategy since 2020, most of these strategies are not structured so much around educational objectives and how they can be achieved using digital tools, but more around big topic areas (digital competences, infrastructure, teaching and learning resources, etc.). A digital transformation of education will require countries to identify more specific purposes of digitalisation.

Once those are specified, governing digital education includes providing access to a digital ecosystem that allows for these objectives to be achieved, that empowers education actors to use digital tools confidently and competently, where trust about the use of personal data is created thanks to privacy and data protection laws and support for relevant staff, that mitigates digitally-induced inequalities and addresses possible systematic biases, and that creates incentives for edtech developers to continue to develop useful and affordable digital tools and resources for education. Several policy levers can be activated for these purpose: incentives to foster interoperability within the system, setting in place risk-management approaches to privacy and data protection, using public procurement, and creating institutions to facilitate the implementation of digital education policies. Rather than being thought of as addressing one specific issue, they can be used to reinforce incentives and address multiple problems.

Interoperability

Interoperability is the capacity to combine and use data from disparate digital tools with ease, coherence and efficiency. It increases the consistency and exchangeability of data collected and maintained by different systems. It reduces the need for ad-hoc processing to re-input, re-format or transform data, so that relevant information can be delivered in a more cost-effective and swift manner to support actions and decisions. In the absence of interoperable digital tools, data linkage and sharing may still be possible but become error prone and time and resource consuming tasks. Interoperability is thus a way to improve efficiency, but also effectiveness of digitalisation (Vincent-Lancrin and González-Sancho, 2023[29]).

Some of the examples of personalisation above require that different systems be able to exchange information. For example, it may not be a problem for standardised assessment evaluations to be stored in a different platform than student information – if those systems are able to communicate and share information easily. If not, it is better to have all the information in the same system (typically the system-level student information system).

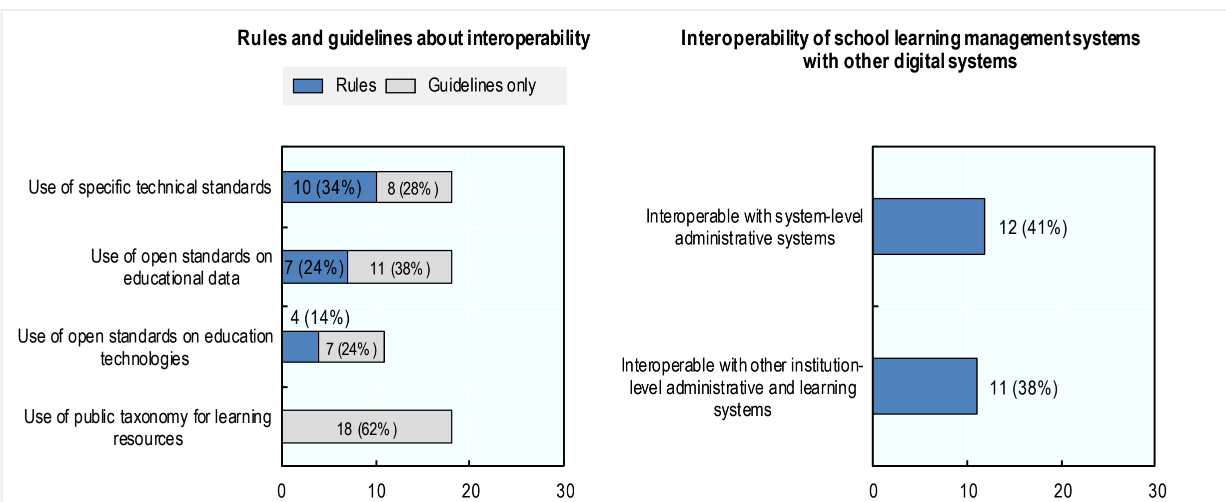
At a system level, interoperability requires a widespread adoption of shared standards, including technical specifications for technology tools and applications, data definitions and code sets, and general models for system architecture. In some cases, it may also require a greater alignment in organisational processes and a legal framework supporting legitimate and innovative ways of using education data.

The transition from a fragmented to an interoperable educational technology and data ecosystem builds on some important policy dimensions. These include dealing with legacy systems (that is, the fact that at any point of time an ecosystem encompasses technologies developed at different times and using different standards), increasing awareness of the benefits of interoperability, putting in place an effective mix of incentives and mandates for the adoption of standards, ensuring sustainability and capacity to adapt to changing needs, and taking advantage of international initiatives in this area.

This book highlights many interesting initiatives to enhance interoperability at the country level. It also shows that this is an area where further efforts are needed. While it is difficult to have precise data without a representative school survey, a minority of countries have rules that mandate some interoperability standards (usually with one or more of their system-level administrative systems) or that require some semantic interoperability for digital learning resources. De facto, in less than one third of the reviewed countries do government officials report that most school learning management systems used by schools are interoperable with system-level management systems or other institution-level digital tools. Should a fully effective digital education ecosystem require interoperability, there is still much progress to make.

While regulating technical interoperability is not necessarily a good idea, there are increasingly technical solutions that can facilitate interoperability. Much more can be done by governments on semantic interoperability, both for administrative data and for digital learning resources. About two thirds of countries and jurisdictions recommend the use of some taxonomy for tagging learning resources, but further effort for developing international standards on content (rather than type of resource) could be made.

Figure 1.6.Interoperability within digital education ecosystems: mandates, incentives and reality (2024)



Note: N=29. The left panel figure shows how many countries use rules or guidelines to encourage different types of interoperability. Ten countries mandate that some systems use specific technical standards (usually to be interoperable with system-level digital systems), while 8 encourage it through guidelines. The right panel figure shows countries where school learning management systems are most commonly interoperable with either system-level digital tools or institution-level digital tools.

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Another option to achieve the same result is to integrate most digital systems into one. In some (usually smaller) countries, some digital tools do integrate most of the functionalities of a typical digital education ecosystem (with the system-level student information system also being a school learning management system, a digital resource platform, etc.). These digital tools are usually directly provided by central governments. They have the advantage of allowing easy data linkages and interoperability, but possibly the disadvantage of not providing choice to schools – and incentives for a local EdTech industry. While it can be argued that an integrated system could be easier to manage from a data protection perspective as fewer, possibly more expert people can take care of the issue, the main vulnerability lies in cyber-security and privacy and data protection (given that all data are held in the “same” place).

Data governance

Strong privacy and data protection is indeed another strong enabler of the digital transformation, both to address objective risks of digital transformation and to create trust in data and AI use in education. Trust in the handling of personal data is necessary to enable the safe and legitimate sharing of data – a necessary condition to harness the opportunities of digitalisation. Privacy and data protection is a multifaceted issue. Two dimensions are considered as a given in this book, but they require strong technical competence and infrastructure and human competence and vigilance: making sure that personal data are protected and not easily hacked (cybersecurity) and making sure that children and students are not exposed to inappropriate content or interactions when using government tools or resources in school (Hooft Graafland, 2018[30]; Ronchi and Robinson, 2019[31]).

Many of the major benefits that a digital transformation of education can bring about rely on the promise of more personalised educational experiences and a stronger knowledge base to design education policies and practices. This usually requires using records stored in silos (if they have shared identifiers). While the sharing and linking of personal education records across different technology tools are central to realising the benefits of digital education, interoperable administrative and instructional systems bring greater privacy and security risks than disparate systems.

Privacy and data protection laws and regulations are essential to prevent privacy breaches and illegitimate uses of personal data. All countries have a privacy and data protection law that applies to education. Most countries that have longitudinal information systems also have specific educational data protection laws or regulations. A risk management framework that recognises a diversity of uses of personal education data, their potential benefits, and their associated privacy risks is best suited to reconcile legitimate privacy concerns with the benefits of using education data to improve educational outcomes.

An important step in the implementation of such a framework is to break away from the expectation of fully eliminating risk in the use of education data. As long as there is an interest in maintaining some analytical value of the collected data, scenarios with zero privacy risks are unrealistic. Another required change is to shift the focus from privacy controls at the stages of data collection and transformation, to a growing emphasis on controls at the stages of data access, sharing and use. Privacy protection should make use of complementary data-focused and governance-focused strategies: data-focused strategies consist of treating data prior to their release or sharing, while governance-focused strategies restrain the interactions of custodians and users with the data both by regulating the conditions for data access and use and by increasing awareness and capacity to address privacy risks. While most countries have published guidelines on the enforcement of their privacy and data protection rules, very few proactively monitor their implementation in school. Privacy awareness campaigns and training programmes have been increasingly implemented as ways of strengthening human safeguards for maintaining the confidentiality of personal data. In Europe, for example, the General Data Protection Regulation requires national data protection authorities to carry out awareness-raising activities for data controllers, processors and individuals, with a special attention to children (Article 57). Providing privacy and data security training to those can help to build a culture of privacy-respectful data use and enhance trust when data are shared.

An increasing number of commercial service providers collect data about students and teachers in formal education. The way they handle data is usually covered by countries' privacy and data regulations, with specific additional restrictions when handling children's data. One aspect that remains largely out of sight of current education policies is the possibility to reuse and share some of the data collected by commercial providers – as is the case for data collected by public educational agencies. Many sectors try to incentivise companies to share some of the data they collect (under data protection laws) to allow for a more vibrant supply of digital tools and resources and more innovation. For example, some of the process information collected by adaptive learning systems might have value for other companies and organisations and allow for the quicker development of new types of digital teaching and learning tools.

Technology governance

As advanced technology allows for more automation and systematic impact on human decisions, or for the capture of increasingly sensitive data such as biometric data, the governance of technology itself is becoming a new concern. Technology governance could, for example, consist of setting some obligations when using automated decision-making, forbidding certain types of technology or technology use, requiring the disclosure of the use of automation, requiring that algorithms are explained or that they are “open” and can be examined by experts, etc.

As of 2024, almost no OECD country regulates technology or algorithms used in education. The only case is France, where algorithms used in public decision-making should be explainable and explained and where certain technology uses are forbidden under normal conditions. Typically, the educational organisation providing digital tools or resources are responsible for their results, but as of 2024 no country reported any use of unsupervised automation in education, let alone the use of high stakes decision making. The emergence of generative artificial intelligence has led to countries publishing a number of guidelines, and two countries have rules pending adoption regarding their use in education (France and Korea) (Vidal, Vincent-Lancrin and Yun, 2023[4]). The European Union is also close to passing an AI Act that will regulate the use of AI tools, making some uses illegal and the use of AI tools in some “high risk” sectors such as education undergo specific processes. Most countries deal with advanced technology with guidelines, and a few countries have published some in the past few years.

One common aspect of those guidelines is the need to keep a “human in the loop”. As AI allows for more automated decision-making to happen, this means that while some recommendations or suggestions could be made by AI, human beings should ultimately make the final decision. This is particularly important when AI tools do not have a perfect performance. Most of the time, this is the current situation in education, but the rule can avoid pitfalls. This rule may also mean that a non-digital alternative should be provided, when possible, both for inclusion reasons and to allow the possibility for people to “opt out” (when possible and appropriate) (Vincent-Lancrin and González-Sancho, 2023[32]).

A second aspect of technology governance lies in the avoidance of algorithmic bias, which is particularly important in education. Algorithmic bias refers to cases where an algorithm advantages (or works better for) some populations compared to others (whether the characteristics relate to gender, race and ethnicity, migration status, etc.). The potential of digital education cannot be fully reached if algorithms that may for example support the personalisation of education replicate or even magnify the biases occurring in societies around the world. Research on algorithmic bias focuses on the performance of AI models for different groups of the population. There are other possible forms (and sources) of bias though. Research on algorithmic bias has mainly been undertaken in the United States so far, including for algorithms and systems operating outside of the United States. It has shown the existence of algorithmic bias based on a variety of student characteristics, but the lack of international research limits the understanding of bias. Policy makers should fund research internationally to better identify the various dimensions of bias in different local contexts. Ultimately, they should support the development of toolkits that would make it cheaper to identify bias. An important take-away is that privacy and data protection should take into consideration the need and importance to collect personal (and sometimes sensitive) data to be capable of detecting (and thus addressing) algorithmic bias and unfair technology. This could be done under a variety of arrangements (Baker, Hawn and Lee, 2023[20]).

Procurement

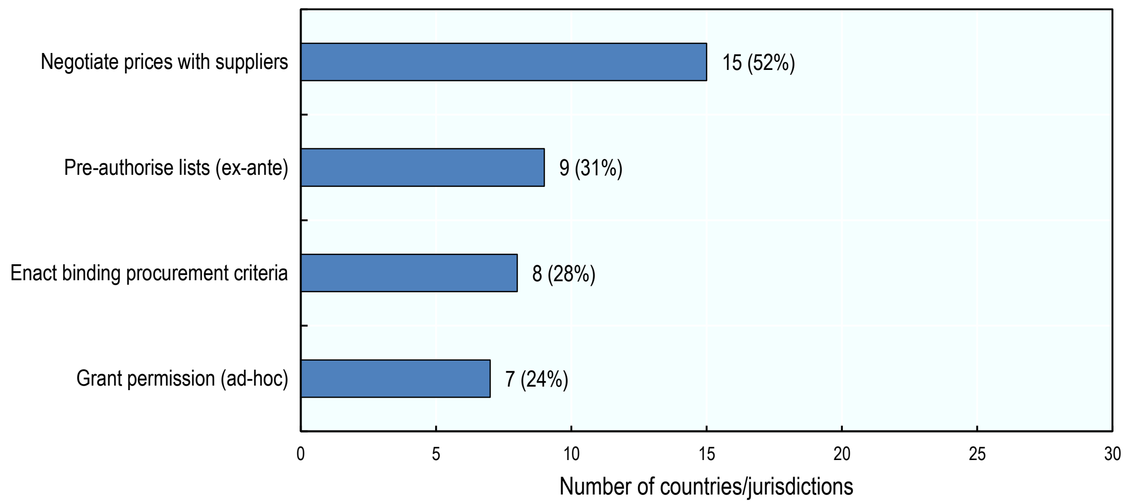
Given that education systems in OECD countries are mainly public, public procurement is a very strong lever to incentivise commercial service and product providers to follow certain guidelines or rules. In an OECD country, public procurement in education represented on average 10.7% of all public procurement in 2021, or 1.4% of a country’s GDP. This is considerable. While the share of digital tools and resources in educational procurement is unknown, one peculiarity of at least some digital devices or tools is that they can be more expensive than usual education materials such as textbooks and benefit more from an aggregated price negotiating power.

Countries already use public procurement as a policy lever to shape their digital ecosystem and foster data protection and security, interoperability, inclusivity and, to some extent, effectiveness. Some countries could however do it in a more proactive way. Countries use multiple, non-exclusive procurement practices. In most countries, governments play a role in the procurement of digital tools and resources, whether for management or teaching and learning. All countries procure digital system-level management tools. Some countries have a mainly centralised approach to procurement (e.g. Czechia, Hungary, Korea, Türkiye) while others leave it to schools to purchase most of their digital educational services and resources (e.g. England, Netherlands) or have a mixed approach (e.g. France, New Zealand). Central procurement supports providing equal access conditions across schools in a country/jurisdiction, greater price negotiation power (thanks to economies of scale), and, in principle, the possibility to rely on more technical competences. More decentralised procurement practices may enable schools (or local education authorities) to choose digital tools and resources that meet their specific needs, even though it might entail higher purchase costs.

For companies, decentralised procurement provides less incentives as it requires a larger sales force, makes the procurement process more varied and complex, and allows less possibilities to scale their offer. This makes entering the market more difficult for small firms. At the same time, a centralised procurement process may limit the number of companies and possibilities to enter the market. Mixing different approaches is thus appropriate for governments to balance access and cost-efficiency, and control of the quality of what is bought with public funds against the provision of market incentives for Edtech suppliers.

Without making the final purchase decision, countries and jurisdictions support their schools and sub-governmental authorities in their procurement through different mechanisms (Figure 1.7). For example, 15 countries negotiate prices with suppliers for some tools; 9 pre-authorise a list of tools and resources to choose from, which gives them the possibility to verify the quality and effectiveness of the resources if they so wish; and 7 countries grant permission on a case-by-case basis, thus allowing for more choice. By attaching product and service criteria to public procurement, governments can help foster a coherent digital ecosystem. As of 2024, 8 countries mandate the public procurement of digital tools and resources according to predefined characteristics: usually tools must meet specific cybersecurity criteria, and less often, interoperability or ecological (sustainability) criteria (Vidal, 2023[33]).

Figure 1.7. Public procurement practices of national or jurisdictional governments (2024)



Note: N=29. 15 governments or subgovernments negotiate prices with commercial vendors, 9 have a list from which schools or lower public authorities can choose from for their procurement, etc.

StatLink https://stat.link/7owxga

Countries could decide to enact more stringent rules for digital education tools to be put on the education market, beyond data protection and cybersecurity standards. They could require tests of effectiveness, the verification of the lack of algorithmic bias, set interoperability requirements with some specific tools, the use of predefined resource taxonomies when appropriate, etc. However, regulation is not always the best option, and they have to also balance these rules against the incentives for commercial providers to develop digital tools and resources. Despite being a large market, education is not always considered a highly profitable one by technology companies, which tend to focus on the education consumer market rather than the formal one.

Co-creation and multi-stakeholder relations

While one challenge for governments is to ensure that commercial providers have enough market incentives to develop quality digital tools and resources for the education sector, another challenge is to ensure the quality, effectiveness, and usefulness of these tools. Traditional education stakeholders usually do not have the competence to develop digital tools for the education sector. Typically, those are developed by for-profit education technology companies, sometimes specifically for the education sector, often by adapting tools that were developed for other sectors to education. It is rare for education ministries to support commercial companies directly, although education technology may benefit from governmental innovation programmes (e.g. for startups or for research and exploratory development). While a few governments support their education technology industry from an international trade perspective, many engage in a dialogue with them by supporting conferences, etc. Education authorities also collaborate relatively rarely with stakeholders such as parents or students when developing or introducing new digital tools and resources.

Acknowledging that education and computer scientists, education technology companies and governments often work in silo, with relatively little involvement of the teaching profession in the definition and development of AI products, new models of research and development of digital technology should arguably be developed. Several models of research and exploratory development are supported by governments that attempt to involve end users more and take an interdisciplinary approach to the development of AI tools and resources in education (Molenaar and Sleegers, 2023[34]). A first approach reflects and adapts a linear approach to innovation: scientific research is translated and transformed into product development and market applications. An increasing number of initiatives work with end users, although not necessarily from the beginning. A second approach focuses on industry development to help start-ups to improve products (propositions) with scientific insights and enhance the ecosystem for companies to thrive and scale up. This model resorts to diverse business development activities, from supporting prototype development, optimising products in multiple schools, diversifying to new sectors in education, through to validating the effectiveness of products to support an evidence-based development of Edtech tools and resources in schools. Other approaches emphasise international collaboration, with similar coordinated projects across countries, or the relationship with teachers and teacher professional development.

For example, the National Education Lab AI (NOLAI) in the Netherlands starts its development process by questions and needs from educational professionals, which are addressed based on scientific insights and recent industry developments. For example, the "happy readers" project started with a request by primary school teachers to be able to better monitor how students' technical reading skills develop over time. Based on what university scholars and industry partners know about reading research and current affordances of technology, such as automated speech recognition algorithms, they developed a new approach to digitally-enhanced reading education.

One of the main purposes of this co-creation would be to develop digital technology tools and resources based on teachers and learners' needs and uses rather than on what is possible given a given state of technology.

Support organisations

Governments should not just fund or establish new types of R-D institutions to allow for multi-stakeholder partnerships in tool and resource development. One of their challenges in implementing their digital strategies lies in the difficulty of ensuring staff have the digital competences to deal with the physical digital infrastructure, with digital tools and resources for management, the pedagogical knowledge regarding digital learning resources and tools, and the ability to support teachers in developing the pedagogical competences to embed the use of these tools and resources in their teaching repertoire. These activities require different expertise than those traditionally available at national or sub-national ministries of education since multi-stakeholder partnerships need to be established, managed, and monitored.

What can we learn from the recent history and transformations of support organisations that countries have established to support the digitalisation of education? Dellagnelo (2023[35]) analyses the advantages and disadvantages of different models, and shows that, while driving the digital transformation from within the ministry of education could be the best solution in some countries, many have opted to externalise this function to a public (and sometimes private) agency as it provided more flexibility to bring the required competences together. The roles to be performed by support organisations need to be adapted to the national context since they may vary considerably according to size of the country, the level of centralisation of the education system, and the existence of other public and private actors in the digital education ecosystem.

To go from the publication of a digital strategy to its actual implementation, governments will need to establish the necessary organisational structure, which will typically mobilise and adapt existing institutions and agencies. However, while there is no foregone conclusion, they may also consider the creation of a specific external support organisation. The trajectory of past support organisations shows that it may be advantageous for them to start by being external before being integrated in the ministry – but all depends on the actual activities involved in the digital strategy and on the competences and capacities already present within the ministry of education.

Monitoring

Finally, while governments sometimes commission research on digital education to their universities or place digital education as a clear priority of their research agenda, it is striking that very few countries actually monitor and evaluate their investments in digital education tools and resources. Information about the physical infrastructure available in schools is missing, not to mention information about uses of digital technology, either as a management tool or as a teaching and learning tool. Nor do countries typically have any research assessing effective versus less effective uses of digital technology at the system, school and classroom levels. It is time for a research effort in this area (OECD, 2023[36]).

Further steps towards a digital transformation

This overview of the findings of the *OECD Digital Education Outlook 2023* shows that countries have made good progress in digitalising their education systems but that most are embarked on a journey towards a digital transition rather than a digital transformation. Most countries now maintain longitudinal student information systems, which they use to produce education statistics mainly, and other system-level digital management tools that support their educational processes: alert systems to enforce compulsory education, digitalisation of exam administration (but not of the exams themselves), digitalisation of national evaluations, etc. They also provide or support the provision of digital teaching and learning resources through a variety of platforms or support services for school procurement. And they encourage the use of digital tools and resources by providing direct training and support to education stakeholders by establishing digital competence standards for pre-service teachers and by making students' digital competences as a transversal objective of their curricula.

However, most of them do not take advantage of the current affordances of advanced digital tools. Very few AI-based educational resources are available in the classroom, and in almost all countries, despite not being designed for educational purposes, AI text generators are the only AI tool that is commonly used by students, with or without the blessing of their teachers. Adaptive learning systems, adaptive assessment systems, adaptive study or careers guidance, and early warning systems are absent from most OECD education systems. Regardless of AI-based digital tools, digitalisation leads to the collection of a significant amount of data across education systems: while those data tend to move up to the national or jurisdictional level, there is much less effort to make this information actionable and used by teachers, students, families, etc.

So far, the governance of digitalisation has mainly focused on avoiding (some of) the possible pitfalls of digital education rather than enabling and unleashing its potential. Countries could take a series of steps to focus on that. Beyond a stronger awareness of the digital education tools and resources that are already available and could be used in their education systems, they should focus on an incremental improvement of their educational processes:

1. *Identify use cases*. How could digital solutions help achieve some of their education policy objectives? In this chapter we took the example of preventing high school dropout, but there are many other educational goals that digitalisation could help address. What kind of data collection would it take to improve these issues? Are these data already collected somewhere? How could they be brought back in a timely manner to the right end users?
2. *Improve student information systems or their use*. Countries that have not yet established a longitudinal information system should consider doing so. Those systems are more effective when schools also have learning management systems that can automatically exchange information with system-level digital tools. While this can take several forms, a major avenue for improving their use is to give back the information that is collected at the education system level to practitioners, in a format that can easily inform their decisions and their thinking.

3. *Develop initiatives to enhance the interoperability of the digital education ecosystem*. A major way to make a digital ecosystem effective and used is to improve interoperability so that data do not have to be re-entered multiple times and that data collected for different administrative and learning purposes can be reused (under usual privacy and data protection regulations). Improving interoperability is difficult as digital technical standards evolve based on research and development rather than administrative will, but it can be done more easily for semantic interoperability. This is also an incremental enterprise that does not require full interoperability among all digital tools in an ecosystem.
4. *Use public procurement practices as a policy lever.* Countries already use public procurement in education as a policy lever. However, many procurement practices follow the lines of traditional devolution of responsibilities as if those were set in stone. While interoperability can be achieved in contexts where responsibility is devolved, it requires more organisational and legal initiatives. Constraints on Edtech providers have to be balanced against the vibrancy of the supply side of the market. Over time, expectations and requirements may increase and procurement could be used to ensure minimal levels of performance of digital tools and resources, the demonstrated absence of bias, and include environmental sustainability criteria.
5. *Balance different needs when regulating.* While regulation is not always the best solution, it is a powerful lever for governments. For example, regulation about privacy and data protection is for example very important, but it has to be supplemented with training and communication efforts towards staff in schools and administrations, and possibly a more proactive support for its implementation. But it is also important that robust privacy regimes do not become the bedrock of unfairness and discrimination among some population groups by preventing possibilities to identify and address algorithmic bias for example. Regulation regarding procurement and other matters should also be balanced with incentives for the business sector to develop digital tools and resources for the education sector.

Beyond these policy pointers to address system-level challenges, the OECD Secretariat and Education International, a union federation that brings together organisations of teachers and other education employees from across the world, have developed a series of guidelines to support the adoption of AI and other digital tools in education. The opportunities, guidelines and guardrails are meant to facilitate discussions between governments, local education authorities and the teaching profession (OECD; Education International, 2023[37]). Box 1.1 presents these guidelines, which supplement the policy pointers presented above.

The *Digital Education Outlook 2023* and its companion, *Country Digital Education Ecosystems and Governance* (OECD, 2023[5]), present the first international comparative analysis of countries' practices and policies. This is a baseline for further international work, highlighting where countries could learn from and get inspired by each other. International work could allow them to move faster towards an effective and equitable digital transformation of education.

Box 1.1. Opportunities, guidelines and guardrails for effective and equitable use of AI in education

The opportunities, guidelines and guardrails for effective and equitable use of AI in education represent positions on the development and use of Artificial Intelligence (AI) and digital education developed by the OECD Secretariat and Education International. This Box focuses on their main headlines.

1. **Equitable access to affordable, high quality connectivity**. Educational jurisdictions should create digital learning infrastructures at a system level that are accessible to all learners and educators in and outside of school. This strategic physical infrastructure should allow for a quick and equitable shift to remote learning if necessary.
2. **Equitable access to and equitable use of digital learning resources.** Educational jurisdictions should make available a set of quality digital learning resources to teachers and students, accessible in school and at home. Teachers should be able to use them at their professional discretion within the context of school and jurisdiction policies. Jurisdictions should provide guidance about usage expectations, in consultation with teachers and other education stakeholders, so that all learners, including educators, can have adequate opportunities to develop their digital skills. This soft infrastructure made up of digital learning resources and tools could provide the positive conditions for a quick and equitable shift to remote learning if necessary.
3. **Teacher agency and professional learning**. The critical and pedagogical uses of up-to-date digital learning resources should become an integral part of teachers, school principals' and other educators' professional competences, fostered in initial education but also within continuous professional learning opportunities and professional collaboration. Recognising the importance of teacher agency, efficacy and leadership is key for allowing them to make a critical use of digital learning resources and design rich learning scenarios with their students.
4. **Student and teacher wellbeing**. The use and development of AI-enabled technology should put learners' and teachers' wellbeing and mental health to the forefront, including by keeping a good balance between digital and non-digital activities. Ethical guidelines on digital communications which recognise that learning is a relational and social experience involving human to human interactions should be created in partnership with teachers and their organisations.
5. **Co-creation of AI-enabled digital learning tools**. Jurisdictions should encourage the involvement of teachers, students and other end users as co-designers in the research and development process of technology to help ensure the usefulness and use of AI-enabled digital tools. An innovation-friendly ecosystem that makes innovation and continuous improvement a culture should allow technology developers to experiment and pilot some tools with the support of teachers and learners.
6. **Research and co-creation of evidence through disciplined innovation**. Jurisdictions should foster research about the effective use of digital tools in education, including practice-engaged research projects that allow teachers to innovate in their classrooms, co-design the uses of technology with researchers that evaluate and document the conditions under which technology use works and for whom. Researcher-led projects can cast light on the most effective uses of AI-enabled technology. In principle, digital transformation

enables quicker feedback and improvement loops than in the past, which education systems should benefit from through an active focus on research.

7. **Ethics, safety and data protection**. Data protection policies should ensure that the collection of data contributes to securing effectiveness and equity in education while protecting students' and teachers' privacy. Educational jurisdictions should provide schools and teachers with clear guidance about data protection and possibly pre-negotiated contracts or guidelines when they resort to commercial solutions. They should ensure that safety or possible algorithmic bias are tested and addressed in their policies. Clear ethical guidelines should also be developed. The ethical use of data about teachers should be negotiated with teachers and their representatives as part of bargaining agreements.

8. **Transparency, explainability and negotiation.** When using digital tools based on advanced technology that are high stakes for students, teachers, or educational establishments, such as digital forms of evaluation and assessment, educational jurisdictions should be transparent about the objectives and processes by which algorithms reach their recommendations. The uses of high stakes digital tools must be discussed and negotiated with all educational stakeholders.

9. **Human support and human alternatives.** As AI-enabled digital tools will allow for increased automation of parts of educational processes, from administration through to teaching and learning, jurisdictions should ensure that learners, teachers, and other education stakeholders can receive timely human support when they face a problem, and, when appropriate, a human alternative to the AI-enabled tool.

Note: The full text is available as chapter 16 of this book.
Source: OECD and Education International

References

Baker, R., A. Hawn and S. Lee (2023), "Algorithmic bias: the state of the situation and policy recommendations", in *OECD Digital Education Outlook 2023. Towards an Effective Digital Education Ecosystem*, OECD Publishing, https://doi.org/10.1787/c74f03de-en. [20]

Belpaeme, T. and F. Tanaka (2021), "Social Robots as educators", in *OECD Digital Education Outlook 2021: Pushing the Frontiers with Artificial Intelligence, Blockchain and Robots*, OECD Publishing, Paris, https://doi.org/10.1787/1c3b1d56-en. [6]

Bowers, A. (2021), "Early Warning systems and indicators of dropping out of upper secondary school: the emerging role of digital technologies", in *OECD, Digital Education Outlook: Pushing the frontiers with AI, blockchain, and robots*, OECD Publishing. [7]

Bowers, A. and R. Sprott (2012), "Examining the multiple trajectories associated with dropping out of high school: a growth mixture model analysis", *The Journal of Educational Research*, Vol. 105/3, pp. 176-195. [14]

Cuban, L. (1986), *Teachers and Machines: The Classroom of Technology Since 1920*, Teachers College Press. [21]

D'Mello, S. (2021), "Improving Student Engagement in and with Digital Learning Technologies", in *OECD, Digital Education Outlook: Pushing the frontiers with AI, blockchain, and robots*, OECD Publishing. [18]

Dellagnelo, L. (2023), "The role of support organisations in implementing digital education policies", in *OECD Digital Education Outlook 2023. Towards an Effective Digital Education Ecosystem*, OECD Publishing, https://doi.org/10.1787/c74f03de-en. [35]

Dillenbourg, P. (2021), "Classroom analytics: Zooming out from a pupil to a classroom", in *OECD Digital Education Outlook 2021: Pushing the Frontiers with Artificial Intelligence, Blockchain and Robots*, OECD Publishing, Paris, https://doi.org/10.1787/336f4ebf-en. [10]

Foster, N. (2023), "Teacher digital competences: formal approaches to their development", in *OECD Digital Education Outlook 2023. Towards an Effective Digital Education Ecosystem*, OECD Publishing, https://doi.org/10.1787/c74f03de-en. [28]

Fragoso, T. (2023), "Hardware: the provision of connectivity and digital devices", in *OECD Digital Education Outlook 2023. Towards an Effective Digital Education Ecosystem*, OECD Publishing, https://doi.org/10.1787/c74f03de-en. [16]

Hooft Graafland, J. (2018), "New technologies and 21st century children: Recent trends and outcomes"*, OECD Education Working Papers*, No. 179, OECD Publishing, Paris, https://doi.org/10.1787/e071a505-en. [30]

Molenaar, I. and P. Sleegers (2023), *Multi-stakeholder collaboration and co-creation: towards responsible application of AI in education*, OECD Publishing, https://doi.org/10.1787/c74f03de-en. [34]

Murphy, R., J. Roschelle, M. Feng, and C. A. Mason (2020), "Investigating Efficacy, Moderator, and Mediators for an Online Mathematics Homework Intervention", *Journal of Research on Educational Effectiveness*, Vol. 13/2, https://doi.org/10.1080/19345747.2019.1710885. [8]

O'Neil, C. (2016), *Weapons of math destruction: how big data increases inequality and threatens democracy*, Crown Publishing. [19]

OECD (2023), *Country Digital Education Ecosystems and Governance. A companion to Digital Education Outlook 2023*, OECD Publishing, https://doi.org/10.1787/906134d4-en. [5]

OECD (2023), "Human resource policies for digital education", in *Shaping Digital Education: Enabling Factors for Quality, Equity and Efficiency*, OECD Publishing, Paris, https://doi.org/10.1787/c7e31038-en. [24]

OECD (2023), *Shaping Digital Education: Enabling Factors for Quality, Equity and Efficiency*, OECD Publishing, Paris, https://doi.org/10.1787/bac4dc9f-en. [36]

OECD (2022), *Education at a Glance 2022: OECD Indicators*, OECD Publishing, Paris, https://doi.org/10.1787/3197152b-en. [2]

OECD (2021), *OECD Digital Education Outlook 2021: Pushing the Frontiers with Artificial Intelligence, Blockchain and Robots*, OECD Publishing, Paris, https://doi.org/10.1787/589b283f-en. [1]

OECD (2020), "The OECD Digital Government Policy Framework: Six dimensions of a Digital Government", *OECD Public Governance Policy Papers*, No. 02, OECD Publishing, Paris, https://doi.org/10.1787/f64fed2a-en. [11]

OECD (2019), "Using digital technologies to improve the design and enforcement of public policies", *OECD Digital Economy Papers*, No. 274, OECD Publishing, Paris, https://doi.org/10.1787/99b9ba70-en. [13]

OECD; Education International (2023), "Opportunities, guidelines and guardrails for effective and equitable use of AI in education", in *OECD Digital Education Outlook 2023. Towards an Effective Digital Education Ecosystem*, OECD Publishing, https://doi.org/10.1787/c74f03de-en. [37]

Reich, J. (2020), *Failure to Disrupt: Why Technology Alone Can't Transform Education*, Harvard University Press. [22]

Ronchi, E. and L. Robinson (2019), "Child protection online", in Burns, T. and F. Gottschalk (eds.), *Educating 21st Century Children: Emotional Well-being in the Digital Age*, OECD Publishing, https://doi.org/10.1787/b7f33425-en. [31]

Roschelle, J., M. Feng, R. Murphy, and C. A. Mason (2016), "Online Mathematics Homework Increases Student Achievement", *AERA Open 2*, Vol. 4, https://doi.org/10.1177/2332858416673968. [9]

Smolenski, N. (2021), "Blockchain for Education: A New Credentialing Ecosystem", in *OECD Digital Education Outlook 2021: Pushing the Frontiers with Artificial Intelligence, Blockchain and Robots*, OECD Publishing, Paris, https://doi.org/10.1787/6893d95a-en. [12]

Thorn, W. and S. Vincent-Lancrin (2021), *Schooling During a Pandemic: The Experience and Outcomes of Schoolchildren During the First Round of COVID-19 Lockdowns*, OECD Publishing, Paris, https://doi.org/10.1787/1c78681e-en. [15]

Vidal, Q. (2023), "Digital assessment", in *OECD Digital Education Outlook. Towards an Effective Digital Education Ecosystem*, OECD Publishing, https://doi.org/10.1787/c74f03de-en. [26]

Vidal, Q. (2023), "Public procurement: shaping digital education ecosystems", in *OECD Digital Education Outlook 2023. Towards an Effective Digital Education Ecosystem*, OECD Publishing, https://doi.org/10.1787/c74f03de-en. [33]

Vidal, Q., S. Vincent-Lancrin and H. Yun (2023), "Emerging governance of generative AI in education", in *OECD Digital Education Outlook 2023. Towards an Effective Digital Education Ecosystem*, OECD Publishing, https://doi.org/10.1787/c74f03de-en. [4]

Vincent-Lancrin, S. (2023), "Learning management systems and other digital tools for system and institutional management", in *OECD Digital Education Outlook 2023. Towards an Effective Digital Education Ecosystem*, OECD Publishing, https://doi.org/10.1787/c74f03de-en. [25]

Vincent-Lancrin, S. (2022), *How Learning Continued during the COVID-19 Pandemic: Global Lessons from Initiatives to Support Learners and Teachers*, OECD Publishing, Paris, https://doi.org/10.1787/bbeca162-en. [3]

Vincent-Lancrin, S. and C. González-Sancho (2023), "Data and technology governance: fostering trust in the use of data", in *OECD Digital Education Outlook 2023. Towards an Effective Digital Education Ecosystem*, OECD Publishing, https://doi.org/10.1787/c74f03de-en. [32]

Vincent-Lancrin, S. and C. González-Sancho (2023), "Education and student information systems", in *OECD Digital Education Outlook 2023. Towards an Effective Digital Education Ecosystem*, OECD Publishing, https://doi.org/10.1787/c74f03de-en. [17]

Vincent-Lancrin, S. and C. González-Sancho (2023), "Interoperability: unifying and maximising data reuse within digital education ecosystems", in *OECD Digital Education Outlook 2023. Towards an Effective Digital Education Ecosystem*, OECD Publishing, https://doi.org/10.1787/c74f03de-en. [29]

Vincent-Lancrin, S. et al. (2019), *Measuring Innovation in Education 2019: What Has Changed in the Classroom?*, Educational Research and Innovation, OECD Publishing, Paris, https://doi.org/10.1787/9789264311671-en. [23]

Yu, J., Q. Vidal and S. Vincent-Lancrin (2023), "Digital teaching and learning resources", in *OECD Digital Education Outlook 2023. Towards an Effective Digital Education Ecosystem*, OECD Publishing, https://doi.org/10.1787/c74f03de-en. [27]

Part I Digital Infrastructure

2 Education and student information systems

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This chapter highlights the importance of a system-level digital tool: student information systems (also known as education management information systems – EMIS). A new generation of student information systems brings together information about each student and their learning trajectory within an education system. This opens the possibility to use the information in real time for some educational decisions and to personalise learning. The chapter presents the common functionalities and uses of these systems within countries, and shows how a next generation of systems could become a key element of an effective digital education ecosystem.

Introduction

A student information system is a digital tool that collects and gives access to detailed information about students, including demographic information, school attendance and pathways, and increasingly their learning outcomes. Contrary to a mere student register, student information systems facilitate access to these data through a range of reporting, visualisation and analysis tools so that they have value for stakeholders in real time. Usually, different stakeholders have access to different kind of information about students, schools and possibly teachers, depending on their role. People with no role in the system can typically not access them. While some of these information systems are typically used for administrative purposes and fed by administrative applications, they are also ultimately used to generate education statistics. Their first value in a modern digital education ecosystem is to provide real-time and actionable information to stakeholders based on the information gathered at the entire system level (González-Sancho and Vincent-Lancrin, 2016[1]).

Student information systems are also referred to as Education Management Information Systems (EMIS), State Data System, State Longitudinal Data System (when longitudinal), or Education Information System. Most of the time, these information systems are not limited to student information. They always include information about schools (and have school unique identifiers) and sometimes teachers as well. Calling them "student information systems" showcases that the current generation of systems usually maintains large data about individual students and that the rest of the information can be connected to students, which makes them "student-centred": most of the time, they also include a lot of data that are not focused on students only, but only linked to them. In this chapter, we will use interchangeably the terms student information system or education information systems (even though the later has a broader connotated scope).

In this report, student information systems always refer to digital systems that are maintained at the system level – as opposed to the institutional/school level. Depending on the country, the boundaries of the education system may be national or correspond to a state/region or a local educational authority. Schools may also use applications called "student information system" or "school information management system" to keep information about their students, including their demographics, their class, their schedule, their parent's information, etc., but for ease of language and consistence over the report, these school-level student information systems will be referred to as learning management systems (Vincent-Lancrin, 2023[2]).

Longitudinal education or student information systems represent a particular class of information systems. In this report, longitudinal student information systems are defined as a systems which: a) connect student-level data collected at different points in time; b) maintain extensive information about students, including about their learning and attainment outcomes, their schooling pathways, and their socio-demographic backgrounds; and c) facilitate data access and data use through a range of reporting, visualisation and analysis tools (adapted from (National Forum on Education Statistics, 2010[3]).

These three basic features are minimal conditions for education information systems to increase their capacity to support more policy relevant and innovative uses of education data, that is, uses that generate a dynamic rather than static view of students' experiences and outcomes, that provide a solid basis for establishing claims about the effectiveness of policies and practices, and that result in more timely and actionable feedback for multiple stakeholders in education. This is why longitudinal information systems will be of particular interest in this chapter.

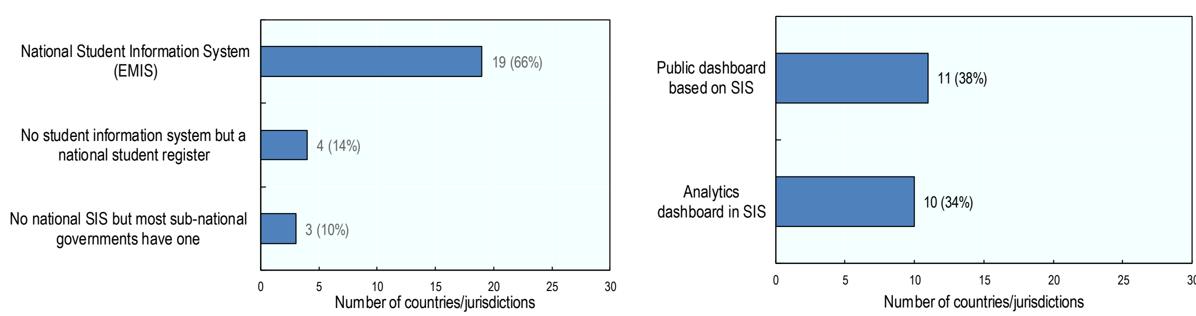
The chapter is organised as follows. The first section presents the prevalence of longitudinal information systems within countries and the main data elements and functionalities of these systems. The second section presents different possible uses of these systems, from a statistical or research use through predictions that help personalise learning. Finally, it reflects on different possible ways of using the information collected by these systems so that it can make the information actionable for teachers and school leaders.

A state of the art

Our comparative analysis covers 29 countries, including two sub-national systems (Belgium) and one OECD accession country (Brazil). All OECD countries were asked to answer the questionnaires. Countries answered a questionnaire, whose answers were validated through interviews of the responding team with the OECD Secretariat. The answers were then double checked and expanded by describing countries' digital education infrastructure and governance (OECD, 2023[4]). Information about other countries is also included when relevant, even if they did not take part in our comparative study.

Most OECD countries have a longitudinal student information system (Table 2.1). Out of 29 countries/systems, 19 (or 65%) have a national/central student information system and 3 federal countries have all or most of their states or regional authorities maintaining a student information system at that level. (For example, all US states and Canadian provinces have a student information system.) Moreover, even though they do not maintain the information through a student information system, four countries collect granular student information as part of a central student register. For a few countries, the system have either a limited scope (for example, SISTEC covers vocational education and training in Brazil) or lacks the integration that a typical information system provides, so that existing applications allow to bring together basic student information, but not in a straightforward way (for example in the French Community of Belgium)). A small number of countries do not have an information system yet, even though they regularly collect information from schools or regions for statistical purposes (for example Japan or Czechia) (Figure 2.1).

Figure 2.1. Number and percentage of education systems with a student information system (2023)



Note: N=29. SIS: Student information system (or EMIS).

StatLink https://stat.link/pes1kq

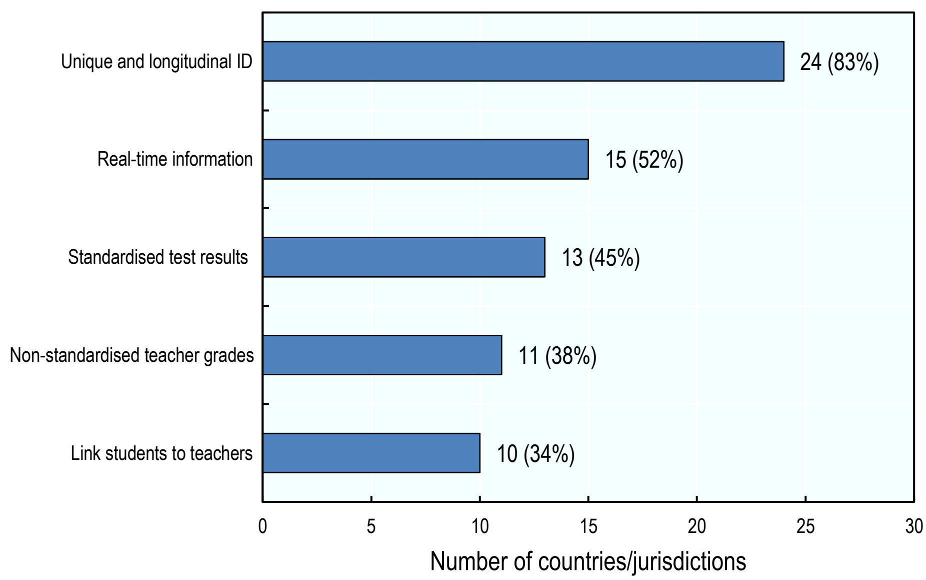
Apart from Mexico, federal countries do not have a central information system or a central student register with student-level micro-data. Typically, states or regions report their information to the federal level: in the United States, states are mandated to provide a certain set of data to the National Center for Education Statistics; in Canada, the Council of Ministers of Education of Canada (CMEC) collects national education statistics in aggregate format through a yearly survey sent to provinces; in Brazil, INEP collects statistics from schools directly (but did not maintain a longitudinal information system or student register as of 2023).

Except in a few cases (e.g. Lithuania and Hungary), where a vendor solution is being used in conjunction with an owned government tool, all those education systems are owned by the government or public authority that manage them. In some cases, this is the customisation of existing commercial solutions; in most cases, the systems have been designed with external companies for the ministry or government agency that owns the tool. The main advantage of ownership lies in the sole ownership (and usually custodianship) of the rich data that are collected. A possible disadvantage lies in the maintenance of the system, which can become obsolete or less performant if no regular investment is made to improve the quality of the reporting and visualisation tools (if any).

Student-level longitudinal tracking

Almost all countries maintain longitudinal student information systems or national student registers: 22 out of 29 countries, that is, 76%, have longitudinal data about their students, either at the national or sub-national levels (Figure 2.2 and Table 2.1). Moreover, 26 countries (90%) can use student-level information to inform their policies and practices, either at the national or other governmental level. Collecting longitudinal information is an essential feature for a modern education information system.

Figure 2.2. Selected data elements in student information systems and student registers (2024)



Note: N=29.

StatLink https://stat.link/1b3hyi

Unique, permanent identifiers that remain with students, teachers, and schools across data collections carried out at different points in time and, eventually, by different agencies or organisations are essential elements of longitudinal information systems. These longitudinal identifiers make it possible to connect data over time and thus trace sequences of events and individual trajectories in the education system. Unique identifiers are also required to match data entities into nested structures, for instance students within classes or schools.

Longitudinal information systems are thus able to follow individual student trajectories over their time in the education systems and, possibly, beyond. At the other end of the spectrum, information systems with a cross-sectional design maintain data collected at one or several points in time and about a single or multiple student cohorts, but lack the capacity to match individual-level records across time.

Unique, permanent identifiers for each individual student are typically assigned to students as they are first recorded in the system, typically as the result of their first school registration process. It usually take the form of numerical or alphanumerical codes. Permanent identifiers remain with students across subsequent data collections, ideally spanning the entire academic history, from early childhood to post-secondary education.

Individual-level identifiers may be specific to a single information system or agency, or shared for use across multiple data systems and agencies. Examples of shared identifiers include social security and ID-card numbers used across government registries, and education numbers that remain with students across their experiences at levels, jurisdictions and schools within the education system. Shared identifiers help establish students' identity unambiguously, facilitate collating data from different sources and reduce the burden of new data collections. However, they raise the stakes for privacy and confidentiality protection, as they are a key to revealing more personal information than identifiers specific to a single database. For example, in Estonia or Luxembourg, students have their national identity number as their unique identifier. In France and in New Zealand, those unique identifiers are by law different for all sectors of society because of privacy concerns. In the first case, it is easier to link all data collected by different administrations, but this requires more trust in the government; in the second case, it is more cumbersome (though not impossible) to link information from different sectors, and the privacy risks are lower.

Permanent identifiers for aggregate-level data entities such as schools and districts are a common feature of education information systems supporting monitoring and evaluation efforts at the school and system levels. However, it is the availability of unique longitudinal identifiers at the individual level – for both students and educators - that constitutes one of the building blocks for more innovative uses of education data. All student information systems maintain school identifiers that support the linkage of school-level information over time – a question that was not asked formally as a previous survey showed that all education systems (surveyed) already have such school level unique identifiers (González-Sancho and Vincent-Lancrin, 2016[1]). All systems therefore have the capacity to describe and compare trends at the system and school levels.

Almost all student information systems in the countries for which we have information cover students in primary and secondary education (including vocational education and training (VET) when provided as part of the school system). In a few cases, there are still different student information systems per level of education: for example France and Luxembourg have two different systems for primary and for secondary education. The coverage of those student information systems depend on the country: in some cases, they cover all students regardless of whether they are enrolled in public or private schools, notably when private schools receive funding from public authorities; in other cases, the systems only cover students enrolled in public schools. The main reason is that those systems inform or are the result of administrative tasks, for example informing school funding, teacher allocation, examination planning, learning assessments, school attendance obligation, etc.

When those systems are multiple, they should be interoperable. In the case of not connected or not interoperable systems, having a unique identifier enables linkages between the data collected by the different systems, but the procedure can take some time and be cumbersome.

Table 2.1. Student information systems: availability and specific characteristics (2024)

	Name of national Student Information System(s) (if any)	Use a national Student Information System	No national SIS but most sub-national governments have one	No student information system but a national student register	Unique and longitudinal ID	Real-time information	Link students to teachers	Standardised assessment results	Non-standardised teacher grades	Analytics dashboard	Public dashboard
Austria	BilDok	✓			✓						
Brazil											
Canada			✓		✓	✓	✓	✓			✓
Chile	SIGE	✓			✓			✓	✓		✓
Czechia											
Denmark				✓	✓			✓	✓		✓
Estonia	EHIS	✓			✓	✓		✓			✓
Finland	KOSKI	✓			✓		✓		✓		✓
France	ONDE and SIECLE	✓			✓	✓	✓		✓	✓	
Hungary	Oktatas	✓			✓	✓	✓		✓	✓	✓
Iceland	INNA	✓			✓	✓	✓	✓	✓		
Ireland				✓							
Italy	SIDI	✓			✓	✓					✓
Japan											
Korea	NEIS	✓			✓	✓		✓	✓	✓	
Latvia	VIIS	✓			✓	✓	✓	✓	✓	✓	
Lithuania	ŠVIS	✓			✓	✓		✓	✓	✓	✓
Luxembourg	Scolaria and Fichiers Elèves	✓			✓	✓	✓		✓	✓	
Mexico	SIGED	✓			✓		✓	✓			✓
Netherlands	DUO	✓			✓						
New Zealand	NSI and ENROL	✓			✓	✓		✓			
Slovenia	CEUVIZ	✓			✓			✓		✓	
Spain			✓		✓	✓	✓				

	Name of national Student Information System(s) (if any)	Use a national Student Information System	No national SIS but most sub-national governments have one	No student information system but a national student register	Unique and longitudinal ID	Real-time information	Link students to teachers	Standardised assessment results	Non-standardised teacher grades	Analytics dashboard	Public dashboard
Sweden				✓	✓						
Türkiye	MEBBIS	✓			✓	✓	✓		✓		
United States			✓		✓	✓		✓		✓	✓
England (United Kingdom)	GIAP and ASP	✓			✓	✓		✓		✓	
Flemish Comm. (Belgium)	Discimus	✓			✓					✓	✓
French Comm. (Belgium)				✓							
Total		**19**	**3**	**4**	**24**	**15**	**10**	**13**	**11**	**10**	**11**
India	VSK	✓								✓	✓
Gujarat (India)	VSK	✓			✓	✓	✓	✓	✓	✓	
Total		**21**	**3**	**4**	**25**	**16**	**11**	**14**	**12**	**12**	**11**

StatLink https://stat.link/zerpq2

Student-level data elements and linkages

The second baseline feature of longitudinal student information systems is the availability of extensive student-level information, ranging from information on the schooling and socio-demographic contexts that they experience to indicators of their academic performance and learning outcomes, when possible.

Longitudinal information systems maintain detailed data about students' participation in the school system over time. This is their minimal function in an education system that allows education administrators to be aware of school enrolments in their country, to ensure students get all the rights provided by law, sometimes to allocate funding to schools – and finally to fuel education statistics, research and feedback to stakeholders.

Student information systems typically include individual-level data on enrolment, school and attendance/absenteeism, study pathway taken, participation in special educational programmes, socio-economic background (or rights to specific benefits such as free or subsidised school meals), all of which reflect critical inputs and factors for student attainment and learning outcomes. In addition, systems typically (or need to include) information about student socio-demographic backgrounds. These data are essential to draw student population profiles in terms of sex, age, family structure, socio-economic status, race and ethnicity, immigration history or other variables that may play a role in their learning or academic performance, as well as to analyse the distribution of student outcomes across these background characteristics. Socio-demographic information may include data elements remaining fixed over time (e.g. birth date, sex) as well as others which may require periodic updates (e.g. family composition, household income) to ensure an accurate depiction of students' out-of-school environments. Most systems collect some of this socio-demographic information.

A 2015 survey of over 60 education information systems (González-Sancho and Vincent-Lancrin, 2016[1]), showed that almost all of them include basic demographic information such as students' age and sex, a smaller proportion of systems maintain data on other family background characteristics commonly associated with student outcomes such as socio-economic status (60% of systems), national origin (69%) or area of residence, and a minority of systems on students' special education status or needs, language spoken at home, family size or other family characteristics. While our comparative data collection did not go in the same depth, the interviews of country representatives showed that most systems (or student registers) have the same basic student data – and likely on average more details about students than in 2015. High-quality information on the secondary dimensions (socio-economic status, race/ethnicity where relevant, immigration status, etc.) is essential to carry out meaningful analyses of gaps in attainment across socio-economic groups or between immigrant and non-immigrant students and or to assess the impact of neighbourhood characteristics on student performance, among others. At the same time, when shared anonymously, these additional characteristics make it easier to possibly re-identify individuals and thus raise privacy issues that need to (and can) be addressed through a variety of techniques.

Information about the organisation and resources of the schools attended by students throughout time is also necessary for gaining a deep understanding of the context in which learning takes place and identifying the factors that can foster or hinder student success, and thus to effectively inform school evaluation and decision making regarding improvement strategies. Countries have differing levels of information about this, and this is currently apparently less often linked to information available within information systems, including where the information is available.

Student outcomes

Student outcomes can be measured and reported through a variety of data. Historically, the focus has largely been placed on end-of-cycle graduation and pathway transitions. These data take the form of exam outcomes (pass or fail), credits gained, grade progression or retention, or completion and graduation at the end of a learning unit, term, school year or educational level. This statutory information is typically available within student information systems and student registers.

While students have received teacher-given grades for ages, in the past few decades educational jurisdictions have gradually developed national evaluations of their education system based on standardised assessments of what they consider key subjects. Digitalisation also allows one to more easily record teacher-given grades.

In this context, there is thus much more scope for education information systems and student registers to maintain student data relating to standardised summative assessments of learning and teacher-given grades at the end of specific courses and grades. Out of 29 countries and jurisdictions for which we have comparative information, 13 (almost half of them) can link student unique identifiers to the results of their jurisdictional standardised assessment and 11 (slightly more than one third) record students' teacher-given grades at the end of some courses or cycles.

In the United States, standardised learning outcomes within states or jurisdictions have become universal, and their outcomes are typically included as a data element in their longitudinal data systems. In other countries, the information is not directly accessible within the student information system (e.g. Italy, Luxembourg or New Zealand), but standardised learning outcomes are typically connected to students' unique identifier and this information can be retrieved through data linkages. Where there is a student register only (e.g. Denmark), this information will be included. European countries often keep information about students' results separate from their student information systems, making them only possible to use for research. In some cases this is justified on privacy grounds. Probably this is related to the institutional administration of the national assessment: in Italy, a specific public agency (INVALSI) is responsible for the national assessment, and it is separate from the ministry of education; in Luxembourg, the University of Luxembourg (LUCET) is responsible for the administration of the national standardised assessment, and it is separate from the ministry of education (or higher education). In France, the national assessment collects information at the school rather than the individual student level, for privacy reasons and as an outcome of collective bargaining.

Most of the national standardised assessments concern literacy (in the national language(s)) and numeracy. In some cases (e.g. Italy, Norway or Sweden), other subjects such as English as a foreign language are also assessed. Teacher-given grades typically cover a wider range of subjects. The need to develop a broad set of knowledge, skills, attitudes and values to prepare students for the future is recognised in the OECD *Education 2030* learning compass (OECD, 2018[5]) as well as in the ongoing work on creativity and critical thinking (Vincent-Lancrin et al., 2019[6]), on creative thinking (OECD, 2023[7]), and the work on socio-emotional learning (OECD, 2021[8]), which highlight the need of developing new teaching, learning and assessment methods to better measure and value a broader set of desired student outcomes. While technical knowledge in specific subjects remains a key dimension of students' education and skills development, the increasing awareness of the importance of this wider range of skills that are useful inside and outside of the classroom are rarely taken into account as part of national assessments or teacher-given assessments, and therefore rarely available within student information systems or central registers (González-Sancho and Vincent-Lancrin, 2016[1]). There is no evidence that this has changed since this previous data collection.

Longitudinal information systems are able to link two of more indicators of student outcomes corresponding to different stages of their trajectories, so that individual student growth trajectories can be analysed. The timeframe of such progression will vary depending on the frequency with which data are collected, but the possibility of linking baseline and follow-up measurements of student outcomes holds the key to move beyond a snapshot description of students' levels of performance and explore, in addition, their evolution over time. Longitudinal data linkages thereby allow a better evaluation of current individual performance in the light of past outcomes. This type of analysis differs from comparisons of school-level performance indicators over time, which may rely on student-level data but do not serve to identify individual learning trajectories. Making learning outcomes data accessible through an education information system can for example allow providing teachers, school leaders or parents with diagnosis information about specific students based on their past trajectory and on lessons learnt from mining information about the entire education system's current and past cohorts.

Teacher-student linkages

Teacher data are another critical component of feedback and analyses seeking to understand the factors that promote student learning. For these purposes, comprehensive education information systems could draw on the administrative teacher and staff data routinely maintained by local and school-based systems, which typically maintain information on the qualifications, years of experience, contract status, and roles and duties assigned to teachers and support staff in schools.

By collecting and maintaining detailed information on teachers and, eventually, other school staff, longitudinal information systems can also help policy makers and administrators to better understand important issues about the teaching workforce. High-quality data on teachers is necessary to analyse teacher supply and demand patterns, the distribution of teacher profiles across schools and districts, attrition and mobility patterns, or questions related to the quality of teacher training programmes or in-service professional development.

In addition, teacher surveys can generate a wealth of information about teacher perceptions and behaviours across a range of dimensions, including professional development needs, teaching practices, school climate or job satisfaction. Survey data from school principals can also contribute to a better understanding of school leadership and school policies, including teacher appraisal and feedback. Where there is enough trust to collect such data, probably by third parties, the availability of unique personal identifiers that teachers would maintain throughout their teaching careers enables longitudinal analyses of these and other questions. Where not possible, usual anonymous surveys remain the way forward. Another source of information might eventually come from some of the tools used by teachers, assuming they can be reliably anonymised.

Further, the possibility of matching teacher and student data brings opportunities to explore the relationship between teacher characteristics and practices and student success. Of the 29 countries and jurisdictions for which we have information, 10 (about one third) have the possibility to link teacher and student data (Table 2.1 and Figure 2.2). Gonzalez-Sancho and Vincent-Lancrin (2016[1]) showed that these linkages were already rare in 2016. In most cases, this stems out of a political compromise with the teaching profession and their representative organisations, for example as a way to build buy-in and avoid some possible uses of the information such as the calculation of teacher "value added" indicators. In principle, to the extent that the information and analysis are used in an ethical way, teacher-student linkages could be beneficial, for example as a way to identify teachers that are particularly successful with certain group of students and understand their practice.

Built-in reporting and analysis tools

The third "basic" feature of longitudinal information systems is the integration of built-in solutions for querying data and automating customised feedback to stakeholders eligible to access the system, ideally using real-time or very recent information. These reporting and analysis tools are complementary to functionalities for data collection and storage. In this respect, an important difference between longitudinal information systems and statistical datasets is that information systems incorporate some form of user interfaces to facilitate data visualisation and analysis as distinct from providing access to raw data (then being processed through statistical packages).

Our comparative information shows that 10 out of 29 countries and jurisdictions (about one third) have dashboard or tools providing data analytics to stakeholders as part of their information system and 15 (that is, about half of them), use real-time information (Table 2.1. and Figure 2.1). Additionally, eleven countries (37%) provide public access to the data they collect through a public dashboard, usually a separate website allowing for ready-made as well as custom data queries (e.g. My School in Australia, Find your school in Ontario (Canada), *Scuola in Chiaro* in Italy, the Education Information Disclosure System (*Hakgyo Allimi*) in Korea, *Skoleporten* from 2015 to 2021 and "Point of view" analysis in Norway).[1]

Examples of user interfaces include data visualisation dashboards, automated reports in print or digital formats, and solutions that enable users to engage in data mining and descriptive statistical analysis of one or more variables (e.g. distributions, cross-tabulations, trends). Analysis and reporting tools can thereby enable comparisons of individual and aggregate-level data relative to benchmarks and allow for adjustments that improve the relevance of these comparisons. More advanced feedback could consist of predictive and diagnostic models that help stakeholders assess current trends and anticipate what might happen in the future (e.g. an early warning system) or the provision of advice based on the data.

Quick and easy access to the data reporting and analysis tools is essential to ensure that the whole range of stakeholders can receive feedback from the information system in a timely manner. The more timely the information, the more valuable it is. Effective reporting tools serve to shorten delays in making information available and speed up the transformation of raw data into contextualised answers to stakeholder questions.

Web-based interfaces offer a practical way to integrate analysis and reporting tools in longitudinal education information systems. Online portals can provide the information most frequently needed by different users in a cost-efficient and flexible manner, for instance by mining data from the system and automatically feeding ready-made reports and featured dashboards in dedicated stakeholder areas of the portal. A single data-querying interface can be designed to provide access to data with varying levels of sensitivity for users with different rights and responsibilities.

Access models

Education data systems may well maintain a goldmine of information and, yet, yield minimal benefits if a large proportion of those who could use the data to inform their decisions cannot do so. Beyond user-friendly reporting and visualisation tools, access policies (who has access to what types of data, and at what level of granularity) critically mediate the value that stakeholders derive from data. Access policies are in principle designed to balance the potential benefits and risks of making available detailed information about students, teachers and schools. Benefits stem, most importantly, from providing enhanced feedback to inform decision-making processes. Risks, on the other hand, may relate to the involuntary disclosure of personal information and the non-intended, controversial uses of the collected data and derived metrics.

A previous study analysed the data access policies of information systems (González-Sancho and Vincent-Lancrin, 2016[1]). Those policies can be characterised across three major dimensions. The first relates to the degree of anonymisation of the individual-level data maintained by the systems. The second concerns the relative scope of coverage across the jurisdiction where the information systems operate. The third pertains to the level of aggregation at which data can be seen. Differentiated access policies can be identified combining these three dimensions.

Table 2.2 summarises the typical conditions for accessing the data maintained for a range of stakeholders (where stakeholders are granted access, which is relatively rare across OECD education systems, given that access is correlated with the availability of dashboard analytics and reporting tools).

Table 2.2. Typical data access conditions, by stakeholder

Stakeholder	Anonymisation	Coverage	Level of aggregation	Proportion of systems providing access to data
Teachers	Class data visible, full anonymisation for all other data	Own class(es) or school	Individual data for taught class(es), aggregated for other information	Low
School leaders	School data visible, full anonymisation for all other data	Own school	Individual data for own school, aggregated for other information	Moderate
Policy makers (administrators)	Anonymised student data, partial access to teacher personal data (few designated people with full access)	Full population in the jurisdiction	Aggregated data for schools and system; individual-level data	All
Researchers	Fully anonymised or synthetic data	Representative sample of school population	Individual-level data	Moderate

StatLink https://stat.link/yjget8

The most restrictive access conditions are those applied to students and families. They can generally access their own and other anonymised data only within their establishment or class, and occasionally some aggregated benchmark indicators at the school-, district- or national-/state- levels, for instance average graduation rates in different schools (or information about the school when a public dashboard is also available). The small proportion of systems giving students and parents access to their data and reporting tools apply strong restrictions along these lines. This follows a privacy logic that students and parents have no reason to know about other students' individual information (even though students may know about the information about their classmates through other channels).

Teachers and school principals have relatively similar rights provided that access to data through visualisation and comparison tools is granted at all, a benefit less often available to teachers than to principals. When access is available, principals and teachers can normally see non-anonymised data required to monitor and support students over whom they have direct responsibilities. However, for both principals and teachers, access tends to be limited to data about students within their own schools or classes. Some systems may allow principals to run comparisons using data from their own schools and like-schools, but not to access individual data files of students attending other schools or campuses. Teachers have generally more limited rights, with access to data from their own classes only (and only rarely the possibility to compare their classes with classes like theirs).

Policy makers and education administrators usually have access to anonymised data across the entire jurisdiction. A small number of designated individuals within local, state or national authorities are generally able to obtain detailed non-anonymised information about all the data subjects followed by the system, but, unless in exceptional circumstances, their access to the information remains subject to strong privacy and confidentiality regulations and thus occurs via anonymised records as for administrators (e.g. superintendents, district leaders, central government officers). This holds true with regard to student data for most student information systems included, while rights on teacher data by certain administrative bodies, especially the inspectorate, more often involve access to personal records.

Lastly, researchers are typically not allowed to access data directly through the information system, but they have access to the anonymised database derived from the information system. In all cases, researchers can only access fully anonymised data, and most often at an individual level. Occasionally researchers have to work with representative samples of the student or teacher population, rather than with datasets covering the entire jurisdiction. A small number of systems make synthetic data files designed to reflect and simulate the true population available for research purposes. In addition, most systems require researchers to meet stringent criteria to gain access to their data. This normally involves the submission of detailed proposals detailing the value and ethical standards of the envisioned research. External researchers can only gain access to cleansed and anonymised data files containing a limited number of variables required for their analyses, rather than to full datasets. Policy makers could make aggregated information available in almost real time to avoid that researchers spend time replicating findings that could be automated.

It is worth noting that no stakeholders are granted extensive access to non-anonymised data. This suggests that there are currently no major privacy or confidentiality risks that may derive from "lax" data access policies. Generally, most systems follow access policies inspired by the "different data for different roles" principle, and which prioritise privacy and confidentiality protection over flexibility of access.

Summary

Most OECD countries have national student information systems, a cornerstone of any digital education infrastructure. Some federal countries have them at the sub-national level, usually with reporting obligations to the central level. However, a few countries lack such systems. While some collect the same data stored in a central student register (which is less actionable), others just collect aggregated statistics.

A key feature of these systems is the use of unique, longitudinal identifiers for schools, students, and sometimes teachers, enabling data linkages over time and over the entire school career of students. They can include extensive student-level data, covering enrolment, attendance, study pathways, socio-economic backgrounds, and other demographics, facilitating the analysis of student outcomes and disparities. These systems also capture student outcomes, such as graduation rates, exam results, credits, and grade progression, with some countries additionally collecting teacher-assigned grades and standardised assessment results.

Data linkages could in principle empower the analysis of individual growth trajectories, enhancing the evaluation of student performance and learning trends, and turn this information collected about all students into actionable information for practitioners in schools.

Only a minority of countries include or link their student information systems with the individual results of their standardised national evaluations (45%), provide dashboards or visualisation tools (31%) to make it easier to use the information in real time, or possess the capability to link teacher and student data (31%), which could possibly provide valuable insights into the impact of teacher characteristics on student success.

A typology of longitudinal information systems

Our international survey covered information about countries' digital infrastructure and governance. A previous survey specifically on longitudinal information systems also collected information about the intended goals and uses of the systems. A great variety exists in terms of information systems' objectives, the nature of their data, their access policies and the functionalities that they enable.[2]. This section proposes four ideal-type models to classify the main functionalities and origins of current longitudinal information systems in education: the reporting and research, e-government, school improvement, and expert system approaches.

The reporting and research approach

A first category of longitudinal information system comes from a statistical and evaluation approach – that is, the traditional approach to the function and strengths of information systems. Unique individual-level identifiers and longitudinal linkages have allowed these systems to enrich their reports and performance cards, but the information produced seek mainly to serve policy makers or to inform the public about general trends in the education system. In some cases, the systems are also meant to develop research capacity about educational issues.

In Ontario (Canada), the Ontario School Information System (OnSIS) collects data to inform decision-making related to education policies, programmes and practices within the province. OnSIS was launched in 2006 as part of the broader Managing Information for Student Achievement (MISA) initiative, whose goal was to build capacity for data use at both the local (school board) and provincial levels. OnSIS collects over 100 million new data records across multiple levels and collections every year. Despite the large growth in the volume of data collected with the introduction of OnSIS, the MISA initiative has enabled a significant decrease in the time required to collect data from boards and an increase in the quality of data. A primary function of OnSIS is to support the ministry's analytical needs and provide key indicators about policy priorities.

The system enables highly granular statistical modelling and trending analysis and a rich contextualisation of student achievement patterns over time. Longitudinal indicators can be constructed at the provincial, school board and school levels, as well as within sub-groups. This enables improved monitoring and a better understanding of the factors relating to student attainment. Longitudinal tracking of individual students is possible through the Ontario Education Number (OEN), a unique student identifier that provides links to data from multiple sources. Uses of linked records include the development of indicators tracking changes in the proportion of students attaining different levels of performance between grades, and examining trends relating to student participation in postsecondary education in Ontario. By collecting timely and quality education data, OnSIS also supports information dissemination through the production of public reports, for instance board progress reports, a school information finder, and trend reports at the provincial level. These products seek to provide timely and consistent evidence to inform strategic planning and decision-making.

In Mexico, the government has established a powerful education information system, SIGE, with student longitudinal information about enrolments coming from schools in all the public schools and states of the country, assessment data (when there was still a national assessment), and a variety of information about schools and teachers. This information is used for some administrative purposes, but mainly to generate reports and allow administrators to monitor the system. The National Institute for Educational Evaluation (INEE) launched in 2016 the *Sistema Integral de Resultados de las Evaluaciones* (SIRE), a new system using SIGE and assessment data to organise and provide visualisation tools for information on the results of student and teacher assessments as well as on the physical and socio-economic context of primary and secondary schools across the country. The SIRE system is designed to support INEE in its mandate to coordinate the evaluation of the education system at federal and state levels, within the frame of the *Sistema Nacional de Educación Educativa* (SNEE).

SIRE informs strategic planning and the design of educational evaluation policies by disseminating contextualised evaluation results to public authorities, educators and parents in an accessible manner. An online portal enables users to customise visualisations of hundreds of variables over 600 geographic layers at local and state levels. The platform also supports dynamic queries into the database, provides reports on key aspects of the evaluation framework, and permits researchers to download aggregated data and establish linkages to external datasets from other government agencies. Some parts are reserved to authorised users within the Ministry. While the pause in the national standardised assessment has reduced the richness of the reporting, this is a powerful system that is an interesting example of central collection of student-level data information in a federal context.

In Latvia, the Ministry of Education and Science developed the governance e-tool Schools Map of Latvia in 2016 as part of a broader project seeking to improve information about school networks. The tool includes an interactive geospatial map of all schools in the country that gives access to school-level indicators such as average results in official examinations, teacher-pupil ratios, study programmes offered, languages of instruction, infrastructure and placements of leaving students, among others. Besides providing an overview of school characteristics, availability of transportation and other local services, the platform enables comparisons of schools' performance as well as analyses of students' mobility trends. The online public version of the Schools Map is designed to help parents and students orient their school choices. Additional functionalities exist for local and central education authorities to assist in decision making for the planning and resourcing of the school system.

Systems built for research purposes are a variant of the reporting and evaluation model. The longitudinal information system of the state of Washington (United States) was designed to improve research capacity to address critical questions for education policy at the state and local levels. Besides the production of feedback reports for policy makers with information on a wide range of programmes and outcomes, the system serves as a data source for educational researchers. It integrates records from multiple agencies across the state into an operational data store with over one billion records about 6 million individuals, making it possible to follow their trajectories from early childhood education through compulsory schooling, post-secondary and into the workforce. To facilitate data sharing across agencies and with external researchers, the state of Washington has established a multi-agency data governance structure. The system relies on a third party for software and assistance in linking identities in its data warehouse.

Some systems such as the New Zealand National Student Index (NSI) was designed to be able to track students longitudinally and is mainly used for statistical purposes: the system, a web platform, allocates to each student a national student number valid from early childhood to tertiary education. School leaders and students use the platform to search and modify the (student's) information in the database records, merge duplicate records, and thus assure the quality of the individual data and of the statistics that can be derived from the database (such as enrolments, graduation, etc.) or from linking distinct databases with students' unique longitudinal identifier. A separate, non-connected system, ENROL, specifically maintains information about enrolments and school attendance at the national level, allowing some interventions to prevent school dropout and enforce mandatory participation in education – as well as statistics on attendance, absenteeism and dropout.

Public websites allowing families and the public to search information about the schools in the country or jurisdiction thanks to the individual data collected and how schools (or districts) compare with other schools give a good (albeit incomplete) public illustration of this approach, and how countries expanded the granularity of their statistical reporting over time.

The e-governance approach

A second type of longitudinal information systems were inspired by an e-government approach, having the main ambition to standardise and increase the efficiency of administrative processes (e.g. school transfer, school choice, university application, etc.). Another important goal behind the design of some of these systems was to optimise financial allocations to schools when funds are based on a student-based formula, which is the case in several OECD countries with such systems. The longitudinal information systems of Korea and Estonia are good examples of the e-government approach, which results in systems with more data and linkage possibilities than systems designed with different approaches, but which tend to have a weaker focus on data use at the school level and on functionalities aimed at supporting instruction.

Korea's National Education Information System (NEIS) is a web-based "one-stop shop" for offices of education, families and teachers, connecting educational and rich administrative information. Its objectives are the sharing of information to achieve improved cost-efficiency and to reduce teachers' workload by freeing them from data entry and verification tasks. The system electronically processes administrative data from about 12 000 schools and 17 metropolitan and regional offices of education across the country. The information is used to manage student admission and enrolment, to record students' standardised test results and teacher-given grades, track student progress and learning trajectory throughout the school year, and transfer student qualifications to other educational institutions (including colleges and universities) in the country. The system also includes teacher information (e.g. their salaries, expenses, and training and development records), the lunch menu of the canteen, etc. Extensive encryption procedures and differential access rights are in place to protect the privacy of sensitive information about students, educators and schools. As an e-government tool, it allows families to create school certificates and sends school permanent records of the third-year students of high school to their applicable university online. It includes interfaces for school leaders, teachers, parents (*NEIS for parents*) and student themselves (*NEIS for students*). The system is also interlinked with those of other 15 government agencies through common unique individual identification numbers.

The automation of administrative processes in schools has significantly reduced the time required for processing documents, leading to cost savings estimated at over USD 200 million per year. The system remains strongly focused on improving administrative efficiency and recent initiatives and improvement have kept this focus. Given the great variety of data elements that it maintains and their high reliability, its data was arguably underused to support more personalised teaching and learning as well as educational research. However, the fourth generation NEIS, which was made available in June 2023, provides data on students' learning history and allows for student course registration and teacher assignment submission. In its original digital governance spirit, its updates contribute to teacher workload's reduction through administrative task automation.

Established in 2005, the Estonian Education Information System (EHIS) is part of Estonia's extensive e-government infrastructure. EHIS and the rest of the national information systems use the X-Road data exchange layer to automate data sharing in a secure Internet-based environment and are accessible to citizens through their ID digital cards. By integrating data from different education registries, EHIS allows individuals to access and manage their personal education and training records across the life course. Applying for university studies by transferring personal details to the desired institutions is the most common use of the EHIS database. The data visualisation web environment *HaridusSlim* (Education Eye) within EHIS provides information about education programmes and institutions across the country in order to support decision making at multiple levels and for different stakeholders, from school choice by students and families to planning and monitoring by local and state policy makers. Plans for development include enriching the information contained in *HaridusSlim* to enable longitudinal analysis of school effectiveness and graduates' success in the labour market.

The school improvement approach

A third type of education information systems puts school improvement at the core of their mission. While sharing many features with systems that have a statistical or evaluation inspiration, systems designed with a school improvement approach make more data available to schools, generally through custom templates and visualisation tools, and seek to provide information at the individual level and with a granularity that makes it potentially usable by teachers (for example, item-level reporting of assessments). However, they tend to target a school improvement approach by targeting school principals (or inspectors) as their main stakeholders. Systems in England and Portugal, Hungary or Gujarat (India) belong to this category.

England created in 2004 the RAISEonline web-based information system for analysing and reporting school performance. Within the context of national standardised assessments, its objective was to encourage school principals to respond proactively to achievement gaps in the performance of their school relative to comparable schools. A self-evaluation objective guided its conception, as reflected in the possibility for schools to personalise reports (e.g. by creating reports on particular groups of students), to add information to the system (e.g. additional information from non-national tests), but also in the restriction of access to school principals and administrators. The system also provided value-added measures of pupil progress that control for contextual factors (ethnic group, poverty status, etc.) and statistical confidence intervals are included in the reports. It was used by over 20 000 schools and 3 000 inspectors across the country to support school self-evaluation and the school inspection process. Since 2017, RAISEonline has been replaced by Analyse School Performance (ASP), a new system co-developed with the Office for Standards in Education (Ofsted) that gives access to the detailed pupil level data that was previously available on RAISEonline and reproduces most of its functionalities, such as enabling schools to analyse their results against other schools nationally and develop “improvement plans”.

In the same spirit, Hungary started collecting information from the National Assessment of Basic Competencies in 2001, but it was only after introducing individual student identifiers in 2007 that the system allowed longitudinal tracking across grades. Since 2010, Hungary has aimed to turn these data into actionable information to school practitioners. Individual reports are available for each student (and the school aggregated reports are open to the public). School principals can connect to the database through the FIT analysis software (FIT elemző szoftver) to make customised comparative reports about their school and students and make comparisons with similar schools. Moreover, the Education Authority, an agency of the Ministry of Interior, provides an expert consultant service through its regional pedagogical centres to help schools and teachers understand and utilise the results. In 2022, new subjects were assessed (science, languages) and expanding the scope of the information is in progress (history and digital culture). In 2023, the covered grades were also broadened to students from 4th to 11th grade. The reporting of results is also currently under revision. The fact that the information maintained by the system is directly accessible to multiple stakeholders (school principals, teachers and students) and that institutional support is provided to schools and teachers for improvement, albeit on a voluntary basis, makes the approach different from the reporting and research systems that typically provide school reports.

In Portugal, the Ministry of Education began piloting the new Escola 360° (E-360°) system in 2017, and in 2022/23 about 150 schools and school networks used it. Portugal was compelled by the economic crisis to improve its capacity to evaluate the efficiency and efficacy of its education system and the E-360° system culminates the process of integrating a previously fragmented education data infrastructure into a new centralised information system. The country had previously developed the MISI information system to collect data from independent school management systems and feeding a separate database per school year. Despite containing very rich data at the individual and school levels, these data were hardly used to inform school decisions. The system did also not enable longitudinal linkages and suffered from poorly defined standards. For these reasons, usage was largely limited to producing yearly reports for budgetary and policy planning. The co-existence of multiple electronic platforms for school procedures led to a duplication of work and sometimes poor communication with stakeholders.

The E-360° system was designed to overcome these limitations. It strengthens the ability of the ministry to produce improved indicators and address policy questions by providing a complete view of student educational paths in a more granular and timely manner, building on the individual student and teacher identifiers of the national e-enrolment system introduced in 2010. In addition to the new collections, the central database incorporates old cross-sectional data series, which were matched with a success rate close to 80%. By integrating all administrative information related to students (e.g. personal background, enrolment and transfers, attendance, assessments) on the same platform, E-360° centralises student management operations, from pre-school to upper-secondary education, supporting the entire processes of enrolment, renewals and transfers of students and automating tasks such as certificate issuing. Moreover, the system seeks to improve the exchange of information from administrative bodies and schools to students and families. Despite those “e-government” functionalities, the platform is maintained by the Directorate for education statistics and science of the Ministry of education and tries to support improvement efforts through the provision of indicators. It plans to develop early warning tools for educators and learning analytics to improve instructional practices. While accessible by all school stakeholders, most functionalities and information seem to be mainly relevant for administrators and school principals (Lopes, 2022[9]).

Gujarat (India) developed an information system called Vidya Samiksha Kendra (VSK) to support its system and school improvement efforts. The system brings together a large number of data and applications that were already collected, but brought them together and added strong visualisation tools and human follow up based on the data. The quality of the data in the system is ensured by a central team verifying on a daily basis that all schools and stakeholders have entered the expected data in the system and following up by phone within a certain period of time if this is not the case. In the Indian context, school improvement is related to student enrolments and attendance as well as the presence of teachers and school network (district) coordinators in school. The system allows for such tracking and intervention, for example by geo-localising school network coordinators in real time. All students take a standard set of short assessments every other Saturday, whose results are entered in the system by data phygitisation (digitising data from the students' physical workbooks by taking a picture of a coded area), which allows to provide regular "report cards" to parents, teachers and school principals about students' progress. Finally, the system allows for pedagogical support through a random selection of classes that are tele-observed by expert teachers, who then provide the observed teachers with feedback. Making the collected information more visible has allowed to better understand some of the shortcomings of the system and to develop new policies such as the "excellence boarding schools" for students from rural areas. The state is also planning to review its school grading system based on the data collected through the system rather than human observation. This is a way to incentivise schools to improve in specific areas (such as infrastructure or teaching and learning).

The expert system approach

Finally, a fourth type of information systems are inspired by "expert systems" that aim to personalise teaching and learning by providing rapid and granular feedback to teachers, students and principals, as well as support materials to enhance learning. These systems are comparable to the school improvement systems in terms of richness of information, but they place yet a greater emphasis on providing actionable feedback to the instructional process. Notably, they tend to provide actionable information to teachers and not just school principals, and thus allow for "class improvement" in addition to "school improvement". Some of their features overlap also with the e-government systems, most commonly linkages with post-secondary education data or from other agencies. They indeed tend to draw on a variety of sources of information to provide comparison and reporting tools related to a variety of pre-identified "business cases". An important feature is that they attempt to provide recommendations to stakeholders beyond mere descriptions. Longitudinal information systems in Colorado (United States), New South Wales (Australia), Charlotte-Mecklenburg (United States) and New York City (United States) can be classified as belonging to this ideal type. The upgrading of a different type of system in New Zealand may also go in the direction of the expert model.

In New South Wales (Australia) a web-based system called SCOUT was launched in 2018, succeeding to an already advanced system (SMART [School Measurement, Assessment, Reporting Toolkit]). The system mainly targets government schools, but provides a more limited set of services to non-government schools. It brings together information from 150 data sources to provide information to school directors, principals and teachers. It notably includes information from national tests (NAPLAN, which all students complete about every two years) as well as exit exams (HSC) and state science diagnosis assessment (VALID). Teachers can customise reports by creating, for instance, specific target groups of pupils whose progress they would like to monitor. The objective is for teachers to gain ownership over the information they are looking at, while providing a tool to map (personalised) teaching into national standards and comparisons. For example, the system offers different comparison tools allowing teachers to compare students' actual performance with their expected growth (given past achievement) or a group of pairs. The system also enables tracking mobile students from one school to another. School principals can also compare their schools to different averages, including schools of similar characteristics, in terms of learning achievements, but also "engagement" (measured by attendance, absenteeism, sick leaves, etc.). While SMART allowed teachers to use a lesson bank and teaching strategies linked to the data available from the website, this does not seem to be the case with SCOUT. However, the system connects the information to each school improvement plan, and goes beyond the "school improvement" approach by allowing detailed comparative analysis about students that can inform decisions at the class and student levels.

Given the wealth and details of information, only eligible people can access the system after a mandatory training.

In New Zealand, the Assessment Tool for Teaching and Learning (e-asTTle) has been in use since 2002. E-asTTle is an educational technology that enables educators to design and generate standardised and curriculum-aligned tests in reading, writing and mathematics in either English or Māori languages, in primary and secondary education. A large bank of calibrated items allows teachers to customise tests to the specific needs of their classrooms. Contrary to other computer-assisted testing systems, e-asTTle was designed with a strong emphasis on formative rather than summative assessment. Tabular reports of students' scores can be easily integrated with schools' student management systems, thus combining information from tailored assessment with school-level administrative and operations data.

An expert feature of e-asTTle is the ability to transforms assessment results into prompt and interpretative feedback for teachers and school leaders through a range of graphical reports. These show student progress and areas of weakness and strength, as well as comparing performance at the individual, class or school levels to curriculum requirements, national averages, or normed gender, ethnicity, language or socio-economic groups. An example is the Individual Learning Pathway report, which gives information on a student's strengths and gaps. Another expert application links assessment results to the What Next website, an indexed library of resources to help teachers and learners identify appropriately targeted learning materials.

In 2015, the New Zealand Ministry of Education launched a Student Information Sharing Initiative (SISI) aiming to bring a strategic perspective on data quality and data management practices to the national school system and to address the problems derived from the use of a wide array of non-integrated IT solutions across New Zealand schools. The proposed solution was a central data repository storing and exchanging core student information between the Ministry and school-level student management systems through interoperable data standards and services. Data and resources from e-asTTle and other assessment tools alongside administrative data were meant to be easily linked within the same application, which would have brought the "expert" functionality to the next level. As of 2023, the initiative seemed to have been interrupted and replaced by other projects withing the Integrated Education Data (iEd) programme, a 5-year policy initiative launched by the Ministry of Education in 2017 with the goal to improve the capacity of the New Zealand education sector to access and use data for improvement purposes.

Charlotte-Mecklenburg Schools (North Carolina, United States), the 17th largest school district in the United States with 146 000 students across 189 schools, has a long experience using its longitudinal information system to facilitate data-informed decision making for school improvement. Besides supporting management and accountability at the district level through quarterly and annual school performance reviews, the Charlotte-Mecklenburg information system puts data in the hands of practitioners with a strong focus on promoting changes in practices at the ground level. Three departments of the district (office of accountability, department of data use for school improvement, department of research, evaluation and analytics) analyse the data they collect to provide actionable information at the district school levels, in line with the "school improvement" approach. Moreover, principals and teachers can use the system to examine a wide array of longitudinal student-level data including interim assessment results, attendance and incidence records that are updated daily. These highly granular indicators are the key input for designing and iterating short instructional cycles in a formative and low-stakes approach to data use at the classroom and school levels.

New York City (United States), the largest school district in the United States, serving over 1 million students in about 1 800 schools, developed and used the Achievement Reporting and Innovation System (ARIS) between 2008 and 2014. ARIS aimed at easing administrative tasks and drive innovation through data use. The development of the data system was informed by this strategic goal and intended to provide local actors with key information to meet their needs (and strong incentives to use the information). The web-based system consisted of three components: an information system providing comparison tools and assessment reports to teachers, principals and administrators about performance (and expected performance) (ARIS); a collaboration tool through web 2.0 tools (wikis, blogs, discussion forums, communities) so that educators could share and refine best practices (ARIS connect); and a tool allowing parents to monitor the progress of their children and giving them information and support to help them (ARIS parent link). Since ARIS was discontinued, the department of education has continued to make a wide range of data available to their staff, families and researchers through its InfoHub portal and the NYC Open Data initiative. While it largely follows a reporting and evaluation approach, employees of the New York City Department of Education, including school principals and teachers, have access to a wealth of additional, more detailed information. Teachers can view their students' report cards, and the city provides a wide range of digital services and tools to its teachers and students.

The state of Colorado (United States) provides public access to information and analysis derived from its longitudinal education information system on the "SchoolView" website. The portal combines four features: a social network for teachers, a learner centre and instructional and assessment resource bank, interactive school performance charts, and access to performance data and reports. While the system does not make recommendations about instructional material and assessment to teachers, bringing all these elements together adds to the school improvement approach. School performance charts are graphical representations of both achievement and growth in achievement. A prime feature is the use of the "Colorado growth model" which expresses growth in performance in percentile form, that is, indicating whether students and schools are improving more or less than the expected improvement for similar students and schools, and therefore presenting growth as a relative rather than absolute concept. Access to such detailed student-level information is available for authorised users only.

More in line with the reporting and research missions, Colorado has also been collecting student-level data from its public higher education institutions since 1988 through the Student Unit Record Data System (SURDS). The Colorado Department of Education has established strong partnerships across agencies to match K-12 data to the wide array of elements in SURDS including application, enrolment, remediation, completion and financial aid student data. These longitudinal matches, going back to 2009 with a success rate of about 94%, allow stakeholders to analyse the factors influencing student post-secondary progress and success, including by disaggregating data by key student demographics and running comparisons between districts and state averages. Another initiative has enabled linkages with earnings data for recent college graduates from the Colorado Department of Labor and Employment, which can be examined by institution or area or study via the College Measures portal. Linkages to data from the National Student Clearinghouse permit to track Colorado high school graduates in out-of-state higher education institutions not included in SURDS.

All these examples give some idea of what an "expert system" approach could look like, even though it may not have fully materialised. The big difference with the school improvement approach is that expert systems use several data sources to try to help teachers and other stakeholders to make decisions about specific students with real-time (the most recent) and past information, usually using diagnosis and predictive digital tools in addition to the human insights and analysis that supports the school improvement approach.

Summary and remarks

This overview shows that strong longitudinal information systems exist in many countries. With no exception, data management tools serve some statistical and evaluation purposes at the system level. Additionally, information systems often facilitate administrative processes and assist families in making their educational choices, most often by providing open information about schools or regions. Less frequently, systems also make data available to schools and educators so that they can devise improvement plans, and in fewer cases, they further provide easy access to instructional material and real-time feedback to personalise teaching and learning processes based on information about current students within a school. The diversity of these systems and of country experiences in developing them is valuable in itself for all countries willing to establish or improve existing systems.

A few countries collect once a year detailed longitudinal information about their students that is recorded in a central student register, that is, an exhaustive database of all students in the system. All countries having a longitudinal student information system also have a student register – but having a database is not the same as having a system that connects to this database and allows some stakeholders to make real-time queries. While they enable strong statistics and post-hoc research on the system and thus align with the research and reporting approach, countries with a mere central student register cannot use them for real-time interventions. (Few countries with a longitudinal information system do so, but in principle they could.)

The ideal types presented above schematise the variety of purposes and functionalities of education information systems. Some countries may have systems using similar data coexist. For example, in England, Analyse School Performance showcased a system geared towards school improvement. However, the system supplements another student information system more aligned with the reporting and research approach though, Get Information About Pupil (GIAP), that includes England's National Pupil Database, its central student register that is intensively used in education research. The GIAP system can also be accessed by specific people within schools and local authorities to find or verify information about specific students (e.g. information about pupil premium funding or end of key stage results), thus also embarking some e-government features.

While a key feature of a modern student information systems lies in the collection of information that connects to students' unique longitudinal identifiers (and sometimes teachers'), most of them initially did this with administrative rather than mere statistical purposes. While some systems have as a primary purpose the generation of statistics about the education system, most of the information is collected for other administrative purposes (and merely re-used for statistical purposes). One of the main original purposes is "funding" or "budget allocation" when based on a formula that requires to know with precision how many students a school enrols. This is for example the case in the Netherlands or in Finland. Some e-government purposes have also been mentioned: the transition of students from one school to another (Korea), the enforcement of mandatory schooling as well as other school obligations in relation to health, social support (New Zealand), or the awarding of or verification of student credentials, or the eligibility to benefits (England, Mexico), etc.

The emergence of national standardised assessments to evaluate the learning outcomes within schools has led to the addition of student learning outcomes as a key piece of information for student information systems, notably when those assessments are conducted with a census methodology (that is, all students of a certain grade within a jurisdiction take the test). (In some cases, it has led to separate digital systems that overlap with other information systems.) Whatever their origin, comparable learning data at different levels of granularity across all students within an education system is indeed the key element that can make student information systems particularly relevant to teachers and school principals.

Reflections on current and upcoming longitudinal information systems

Diversity or convergence

Moving forward, education agencies will likely invest to expand the capabilities of their information systems in multiple directions, from incorporating new and higher quality data, to enhancing linkages and analytic functionalities, and to improving conditions for access for and actual use by different stakeholders.

In fact, the evolution of student information systems over time seems to be about encompassing more and more functionalities. For example, while the very rich Korean National Education Information System was hardly used for research purposes initially, access to its data have eventually been open to researchers, allowing to strengthen its "research and reporting" purpose. It is possible that, in the future, it will also be used for school or improvement, and perhaps even as an expert system. Another example is the awarding of credentials: once they become longitudinal and include trusted information, what was initially statistical can be turned into a credential awarding system, a typical e-government functionality.

In some cases, the evolution can go in the opposite direction, as several systems that included many "expert system" features were also dismantled and replaced. Developing information systems and embedding data use in schools requires building trust among education stakeholders. On the one hand, collaboration between different agencies is essential to establish data sharing agreements that expand possibilities to use data for educational improvement. These partnerships depend on institutional trust and mechanisms that ensure that all parties have a say in the questions that the data should help address. Trust can emerge from regulatory frameworks that promote data integration while protecting privacy and data ownership, but also from a common understanding of the purposes and functions of information systems. On the other hand, turning data use into a routine activity in schools requires that practitioners perceive information systems as tools that serve to support their work rather than instruments to meet reporting and accountability requirements. They also have to be useful tools that provide insights that would be difficult to have without the use of the data.

Will the slow but continuous development of longitudinal student information systems lead to a gradual confluence internationally around specific design features? This remains an open question. However, systems need not converge towards a single approach to how education data could and should be used to be effective. In fact, the variety of goals and motivations revealed by current and previous work (see (González-Sancho and Vincent-Lancrin, 2016[1])), and the country, regional and local experiences presented in this chapter and in the related report (OECD, 2023[4]) suggest that the diversity of approaches will stay to meet a range of varying needs, not the least because these information systems also reflect a range of varying governance arrangements across countries. Rather than focusing on a single model, the next generation of longitudinal information systems in education will likely develop in many different yet complementary ways. The case uses of the systems and how the information can be brought into the hands of practitioners (and researchers) may matter more than the actual architecture or initial purpose of the student information system.

Integration or interoperability

A wealth of data is collected daily in education. However, not all this information is actionable to improve student and teacher learning or simply administrative processes. Data are sometimes maintained in silos that cannot communicate with each other and pieces of information that would gain in value if linked across data subjects and time remain disconnected. Different digital applications have usually taken care of all these different functionalities, and the strength of some information lies in making the data collected and managed by different applications accessible by one specific system to provide information according to a specific, identified need that can add value to stakeholders' decision making.

Should next-generation longitudinal education or student information systems be a gigantic one-stop shop for all educational data? Not necessarily. Full integration of existing data systems would be difficult to achieve and raise security problems. This is a possible model, but it is in fact not required. The most advanced systems can already “mash up” data from separate, independent sources, and this is likely how next-generation systems will work, bringing data in so-called “data lakes” that are mined for different purposes.

Integrated systems with a multiplicity of functionalities could be seen as a possible ideal as it typically provides access to all stakeholders in the systems. Two examples of such systems can be found in Iceland and Luxembourg (secondary education). In these two countries with a small population, the central student information system is also a school learning management system. Different stakeholders have different authorised accesses and uses, but all the data are held together within the same system and one could easily imagine how they could easily be linked and turned into “expert systems”. As of 2023, Iceland does not have a national standardised assessment that would allow its stakeholders to compare a specific class or student to his or to past student cohorts, and the national assessment in Luxembourg is kept separate from the two national student information systems. The education systems presented above in New South Wales (Australia) and Gujarat (India) follow this idea of “mash up”.

The ability to integrate data from different systems and applications without having an integrated system relies critically on the adoption of interoperability standards (see Vincent-Lancrin and González-Sancho (2023[10])). Standards create a common language to overcome the problems arising from the use of different formats and definitions for education data elements. Greater interoperability also facilitates that personal records can follow individuals when they cross jurisdictional boundaries, for example within federal countries (Box 2.1). Importantly, more interoperable information systems would permit to improve speed of feedback. A substantial share of systems still takes several months to provide information based on student data (assessment and others), thus providing little room for teachers, administrators and families to make a formative use of this information. Data-driven organisational routines often have to rely on information about past rather than current students.

Box 2.1. Education information systems: the federal challenge

The examples from the United States, India and Mexico

Federal countries and countries with a strong devolution of education to sub-national governments and authorities face specific challenges with education information systems. The national government can typically only incentivise each state, region, province or local education authority to develop or maintain a longitudinal information system, even though it usually mandates the reporting of certain data and statistics.

The United States has been successful in supporting the development of "statewide longitudinal data systems" (SLDS) grant programme of the National Center for Education Statistics: since 2005, it has awarded over USD 800 million to nearly all US states and territories and provided them with technical assistance. The first grant programmes focused on the establishment of a longitudinal data system, then on student-teacher linkages, while the programmes now focus on the improvement of existing infrastructures and the use of the data to improve practice. A number of non-governmental actors have also supported the agenda, which led to all US states having a longitudinal student information system in 2023. As these systems are typically not interoperable, and do often not allow to track students once they cross a US state border, a common data standards initiative was launched in 2009 to work on and publish recommended standards for data elements and document existing state standards. This has allowed for some level of convergence or at least opened more possibilities to compare data across states.

Recent efforts in India to establish information systems in all its states and at the central level as part of the National Digital Education Architecture (NDEAR) launched in 2021 illustrate a different approach. At the central level, the Central Institute of Educational Technology (CIET) at the National Council of Educational Research And Training (NCERT) developed a central education information system called Vidya Samiksha Kendra (VSK) that present data visualisations for the centrally collected information about the country (enrolments, results to the national standardised assessment, national funding provided to different states, etc.). While the first VSK was developed by the state of Gujarat (India), CIET-NCERT has supported the development of state-wide VSKs by providing grants to all states and, perhaps more importantly, an open source VSK platform that states can customise, further develop and share new elements with other states in the spirit of the open software movement. While there is no obligation to adopt any particular approach, a mix of strong incentives, grants and the provision of standards embedded in software may lead to the adoption of such platforms but also perhaps to greater interoperability across states.

Despite being federal, Mexico has developed a national longitudinal student information system by collecting information about students, teachers and schools directly (for all public schools in the country). SIGED contains data from the entire Mexican education system – students, teachers and school staff, and schools – as well as documents and information on credentials, thus serving as an education management information system, a student information system, and a platform for digital credentials. Data entry into SIGED is mandatory. SIGED serves a variety of purposes, from funding schools, generating credentials to providing granular statistics.

A vision for the next generation of information systems

Over the next 5 to 10 years, education information systems could be expected to gradually incorporate a series of advanced features that exemplify innovative and promising solutions for the evolution of longitudinal systems. "Next-generation" longitudinal information systems with these advances features could set the horizon for education agencies working towards building an enhanced data infrastructure to meet the challenges and seize the opportunities of the digital transformation. In particular, recent technology developments support the help of privacy (see (Vincent-Lancrin and González-Sancho, 2023[11])).[3]

Higher order capabilities of information systems may involve, among others, the ability to collect data of greater granularity, the provision of real-time feedback through customisable reporting tools, links to banks of digital learning resources, or the integration of automated diagnostics and recommendation solutions to help personalise teaching and learning practices (González-Sancho and Vincent-Lancrin, 2016[1]). Current information systems in education could incorporate these features in a gradual manner.

Next-generation systems could be characterised by the ability to combine administrative education data with data from digital learning and assessment platforms that provides a more granular view of the learning process. Relying on the combination of different types of data, next-generation systems could then be powered by learning analytics and other techniques to make customised recommendations and provide links to specific instructional and learning materials. The application of learning analytics would enable systems to organise the navigation of banks of resources through techniques such as knowledge domain modelling, which uses personal data to compare a learner's knowledge with the mapping of knowledge in a discipline and provide personalised content and tasks to support progress in learning (Siemens, 2013[12]) (Lang et al., 2017[13]). The same "detect, diagnose, act" process as in adaptive learning systems focusing on task-level learning (Molenaar, 2021[14]) could be replicated at a more macro level, that is, study paths and integrate different sources of information about student learning.

Currently, most of the student assessment data included in education information systems are summative data in a small number of subjects coming from national/jurisdictional standardised assessments. Few system collects data from teacher-made assessments, from formative assessments, nor data about creative and critical skills or social and behavioural skills, even though some systems maintain data about actual student behaviour. One challenge for next-generation systems will also be to include broader data elements about the learning process than those measured by most standardised tests (reading, maths or science) so as to support a holistic education (OECD, 2019[15]).

Developing systems in this direction would require the adoption of interoperability standards to enable data mining and data linkage across platforms (see (Vidal, 2023[16]))). Data integration does not necessarily involve transferring data from multiple sources into a single system. Instead, integration can more easily be achieved by making systems interoperable, that is, making them able to read, mine and link data from one another. Open technical standards and definitions pave the way for this type of integration, so that data from multiple feeding databases can be combined and analysed through a single system or interface.

Another essential feature of next-generation systems would be a greater integration of analysis and reporting tools to facilitate feedback and knowledge flows. Rapid feedback loops that keep pace with data generation cycles can enable more dynamic learning environments for students and teachers, as well as the faster evaluation of interventions by educational researchers and policymakers. At the school level, enhanced analysis and reporting tools would include automated reports, flexible data visualisation interfaces such as customisable dashboards, and discussion tools. For researchers and administrators, enhanced analytical capacity would stem from reduced delays in the turnaround of data and a greater ability to make relevant comparisons between schools and programmes.

Building on prior waves of systems designed to provide an overview of student and school performance at the system level, the main aim of future systems should be to foster improvement by giving quick feedback and supportive tools to teachers, schools and students. An initial step to enable a closer examination of instructional practices would be to establish student-teacher and student-course data links within longitudinal systems. The enhanced capabilities of next-generation information systems would thus open the door for a forward-looking re-orientation of the use of education data, away from a traditional focus on reporting and accountability purposes and towards informing concrete practices in teaching and learning.

References

González-Sancho, C. and S. Vincent-Lancrin (2016), “Transforming education by using a new generation of information systems”, *Policy Futures in Education*, Vol. 14/6, pp. 741-758, https://doi.org/10.1177/1478210316649287. [1]

Lang, C; G. Siemens; A. Wise; D. Gašević (2017), *Handbook of Learning Analytics*, Society for Learning Analytics Research (SOLAR), https://solaresearch.org/wp-content/uploads/2017/05/hla17.pdf (accessed on 9 January 2018). [13]

Lopes, F. (2022), *Plataformas Eletrónicas de Gestão de Alunos - A Plataforma e360*, https://repositorio.iscte-iul.pt/bitstream/10071/27377/1/master_fernando_mateus_lopes.pdf. [9]

Molenaar, I. (2021), “Personalisation of learning: Towards hybrid human-AI learning technologies”, in *OECD Digital Education Outlook 2021, Pushing the Frontiers with Artificial Intelligence, Blockchain and Robots*, OECD Publishing, https://doi.org/10.1787/589b283f-en. [14]

National Forum on Education Statistics (2010), *Traveling Through Time: The Forum Guide to Longitudinal Data Systems. Book One of Four: What is an LDS?*. [3]

OECD (2023), *Country Digital Education Ecosystems and Governance. A companion to Digital Education Outlook 2023*, OECD Publishing, https://doi.org/10.1787/906134d4-en. [4]

OECD (2023), *PISA 2022 Creative Thinking Framework*, OECD Publishing, https://doi.org/10.1787/dfe0bf9c-en. [7]

OECD (2021), *Beyond Academic Learning: First Results from the Survey of Social and Emotional Skills*, OECD Publishing, https://doi.org/10.1787/92a11084-en. [8]

OECD (2019), *Measuring Innovation in Education 2019: What has changed in the classroom?*, OECD, https://doi.org/10.1787/9789264311671-en. [17]

OECD (2019), *OECD Learning Compass 2030*, OECD Publishing, https://www.oecd.org/education/2030-project/teaching-and-learning/learning/learning-compass-2030/OECD_Learning_Compass_2030_concept_note.pdf. [15]

OECD (2018), *The Future of Education and Skills. Education 2030*, OECD, Paris, http://www.oecd.org/education/2030/E2030%20Position%20Paper%20(05.04.2018).pdf (accessed on 28 November 2018). [5]

Siemens, G. (2013), “Learning Analytics: The Emergence of a Discipline”, *American Behavioral Scientist*, Vol. 57/10, pp. 1380-1400, https://doi.org/10.1177/0002764213498851. [12]

Vidal, Q. (2023), “Digital assessment”, in *OECD Digital Education Outlook. Towards an Effective Digital Education Ecosystem*, OECD Publishing, https://doi.org/10.1787/c74f03de-en. [16]

Vincent-Lancrin, S. (2023), “Learning management systems and other digital tools for system and institutional management”, in *OECD Digital Education Outlook 2023. Towards an Effective Digital Education Ecosystem*, OECD Publishing, https://doi.org/10.1787/c74f03de-en. [2]

Vincent-Lancrin, S. and C. González-Sancho (2023), “Data and technology governance: fostering trust in the use of data”, in *OECD Digital Education Outlook 2023. Towards an Effective Digital Education Ecosystem*, OECD Publishing, https://doi.org/10.1787/c74f03de-en. [11]

Vincent-Lancrin, S. and C. González-Sancho (2023), “Interoperability: unifying and maximising data reuse within digital education ecosystems”, in *OECD Digital Education Outlook 2023. Towards an Effective Digital Education Ecosystem*, OECD Publishing, https://doi.org/10.1787/c74f03de-en. [10]

incent-Lancrin, S.; C. González-Sancho; M. Bouckaert; F. de Luca; M. Fernández-Barrerra; G. Jacotin; J. Urgel; Q. Vidal (2019), *Fostering Students’ Creativity and Critical Thinking: What it Means in School*, Educational Research and Innovation, OECD Publishing, Paris, https://doi.org/10.1787/62212c37-en. [6]

Notes

[1] https://www.myschool.edu.au/; https://www.ontario.ca/page/find-your-school; https://cercalatuascuola.istruzione.it/cercalatuascuola/; https://www.schoolinfo.go.kr; https://www.udir.no/kvalitet-og-kompetanse/stastedsanalyse/om-stastedaanalysen-for-skoler/.

[2] Complementary to the rich details obtained through the survey about the capabilities and data maintained by the systems, interviews with countries as well as a past survey on longitudinal information systems (González-Sancho and Vincent-Lancrin, 2016[1]), the section builds on a series of international meetings to gain further insights into the current and potential roles of these information systems and to foster peer learning among chief data officers and system managers across countries. Two workshops were held in New York City in June 2010 (in collaboration with the US Social Science Research Council (SSRC) and the Stupski Foundation) and in 2014 (hosted by Barnard College, Columbia University). A third meeting was organised in Washington DC in December 2015 in collaboration with the American Educational Research Association (AERA). Overall, more than 100 participants from 25 countries attended these meetings. The OECD Secretariat continues to be active and participates in the expert groups organised by the United Nations Educational, Scientific and Cultural Organisation (UNESCO).

[3] See for example the US strategy about these technological advances: https://www.whitehouse.gov/wp-content/uploads/2023/03/National-Strategy-to-Advance-Privacy-Preserving-Data-Sharing-and-Analytics.pdf.

3 Learning management systems and other digital tools for system and institutional management

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This chapter presents an overview of the nature of provision and type of functionalities of software or platforms used for managing schools within countries and jurisdictions: learning management systems, digital tools for managing student enrolments and admissions, credentials, preventing dropout as well as study and careers advice platforms to students and teachers. The chapter discusses the state of countries' digital ecosystem and the pros and cons of different types of public provision.

Introduction

Digital education infrastructures are comprised of many digital tools and resources to support administrative and educational operations at the system and at the institutional level. This chapter aims to provide an overview of countries' digital infrastructure related to institutional and some system-level management tools. Two other chapters cover specific system-level digital tools: students information systems (or EMIS [education management information systems]) (Vincent-Lancrin and González-Sancho, 2023[1]) and digital tools that support the administration of national assessments and exams (Vidal, 2023[2]). The provision of and access to teaching and learning resources is covered separately (Yu, Vidal and Vincent-Lancrin, 2023[3]). This chapter is concerned with software rather than hardware (Fragoso, 2023[4]). It provides an overview of what countries/jurisdictions provide publicly and what is available to schools, teachers and students based on a survey to which 29 countries/jurisdictions responded. The information was expanded while picturing countries' digital education infrastructure and governance (OECD, 2023[5]) which provide additional information on countries' digital platforms and tools as well as links and references.

The chapter presents the nature of provision and type of functionalities of software or platforms used for 1) managing schools, 2) managing student enrolments, admissions credentials and preventing dropout 3) providing study and careers advice to students and teachers.

The first section will cover the following types of tools: learning management systems, understood as digital tools to manage students' attendance, classes, grades and sometimes to manage teaching and learning content; customer relationship management systems to communicate with parents, students and possibly other parties; administrative systems to manage pay, contracts, etc.; and facility management systems to manage the use of school buildings. The provision and functionalities of learning management systems are presented in more detail given their importance at the local level but also at the system level to feed and receive information from the national (or jurisdictional) student information system. The second section presents admission/registration systems, digital credentialing tools as well as alert and early warning systems designed to address school dropout. The third section presents study and careers guidance platforms aimed at students and at teachers.

The conclusion then provides a summary of the information and makes some suggestions for policy makers to consider. It notes the lack of monitoring by countries of the actual usage of different digital tools, highlights the gap between current technology affordances and the more basic functionalities of most tools, and suggests that, beyond the benefits of digitising specific tasks for efficiency purposes, policy makers and other stakeholders should reflect about how information spread out in their system could help achieve some of their strategic policy goals.

Managing schools

Learning management systems

Learning management systems (LMS) are the school equivalent of student information systems for administrators – although they typically have more functionalities. They can be referred to with many different names (e.g. course management system, school information management system, school administration system, student information system, content management system). In this book, a learning management system will be defined as a software used for the administration, documentation, tracking, reporting, automation, and delivery of educational courses and programmes to students.

At a minimum, learning management systems have the functionalities of a local student information system: they typically collect and organise personal information about students such as their name, (school and or system-level) unique identifier, address, age, parental contact information, class, course(s) and teacher(s), presence and absences, grades, eligibility to school-related social benefits (and thus, directly or indirectly, parental socio-economic status), and at a minimum any other demographic or learning characteristic that will open them some rights in their school or education system. In this minimal format, a learning management system manages learning by documenting what students study, with whom (peers and teachers), their assiduity (absences and attendance), their progress (grades and progression over time) as well as other aspects of their learning (e.g. discipline). Whether these functionalities are digitised or not, they are essential to managing an educational establishment, especially when students are minor and to some extent under the responsibility of schools. They are also important where formal education is mandatory in order for this obligation to be enforced. In some cases, they include the possibility to communicate with parents/guardians and let them know about absences and other relevant information.

A second functionality that some learning management systems have is “content management”. They allow teaching staff and institutions to create and manage lessons, courses, quizzes and other learning/training materials. In that case, they not only manage the administrative learning of students, but also the learning content. They may be used to give access to public or digital learning resources, allow students to communicate with their teachers and sometimes classmates in a closed environment – and in some cases provide some other functionalities such as videoconferencing (virtual classes, etc.).

Finally, learning management systems increasingly include reports and analytics about the data collected within the system. They could report on the percentage of absent students and staff over time, compare different classes or student cohorts for given tests or exams, grade point average, or other characteristics such as socio-economic status. They could also provide predictive or diagnosis analytics, whose accuracy will depend on the software but also breadth of the data collected. This information will be useful for teachers and administrators depending on the quality and legibility of the data, usually presented through a dashboard. Over time, one can imagine that the advancement of generative AI and other chatbots will allow teachers to receive the information through questions and answers, in natural language, or a mix of natural language and figures. The development of other forms of AI may also lead to the incorporation of suggestions for teachers, administrators, and students themselves about teaching, learning and administrative strategies to achieve their goals.

Typically, learning management systems are closed systems and only school administrators, teaching staff and learners who are enrolled in a given school (or given network of schools) can access them. They will have authorised roles that will only allow them to see information that is relevant to them: administrators will see most or all the information in their school; teachers, information about their students and aggregate information about their school; students, their own information, and possibly how it compares with their class. And parents will typically be the recipients of emails or texts, and sometimes have access to information about their children (grades, absences, timetable, communications).

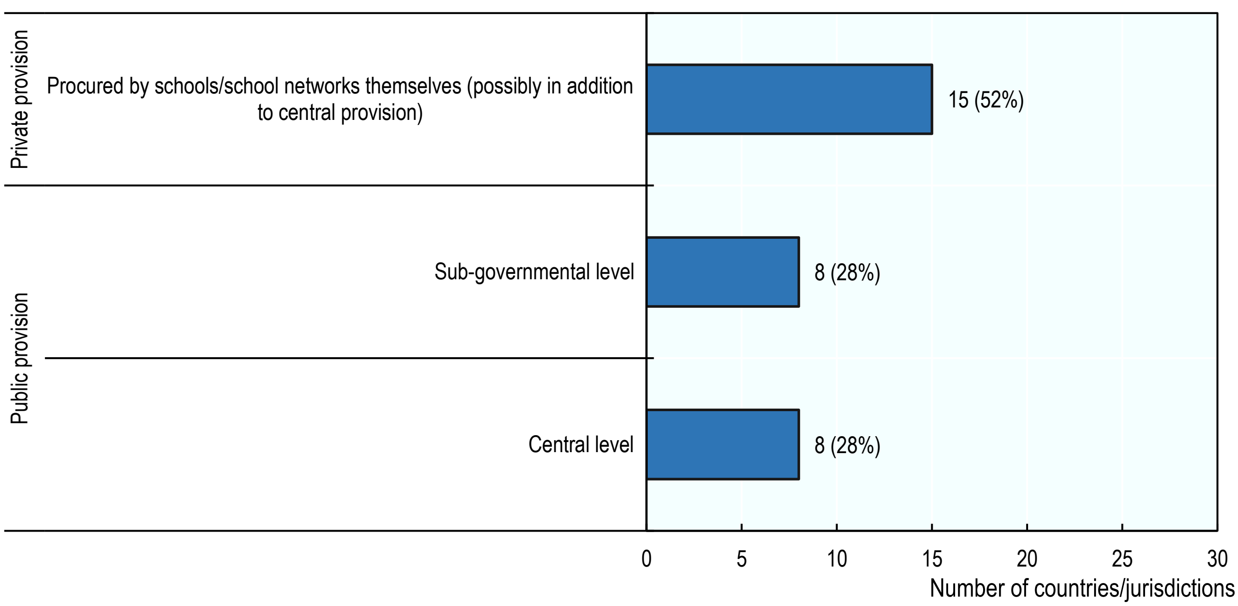
There may be other digital forms of managing student and school information that are not considered to be learning management systems, although they may cover similar functions in a usually less efficient way. Using a spreadsheet would be one example. This information can also be maintained in paper form – and is still in many countries, which limits the possibilities to leverage the gathered information to make it actionable (and is arguably less cost-efficient). Conversely, even though applications such as Google Classroom and Microsoft 365 Education are not always considered as full learning management systems as their main functionalities lies in digital tools that are not usually included in learning management systems, they are often, de facto, used as learning management systems as well, notably for the content management part.

For the same reasons as longitudinal information systems, learning management systems are more helpful when students are tracked through a unique, longitudinal identifier.

Where countries stand

The OECD survey on digital infrastructure and governance shows that the public provision (or procurement of) learning management systems is less common than that of system-level student information systems: 8 countries/jurisdictions (out of 29) provide learning management systems at the central level (and some states and provinces in the United States and in Canada do so as well); in 8 other countries, they publicly provided at the sub-governmental level (typically either regions or municipalities); finally, in 15 others they are procured directly by schools, usually with public funds, and possibly in addition to the learning management system provided by educational authorities (see Figure 3.1 and Table 3.1 for details).

Figure 3.1. Nature of provision or procurement of learning management systems (2024)



Note: N=29.

StatLink https://stat.link/cfwpny

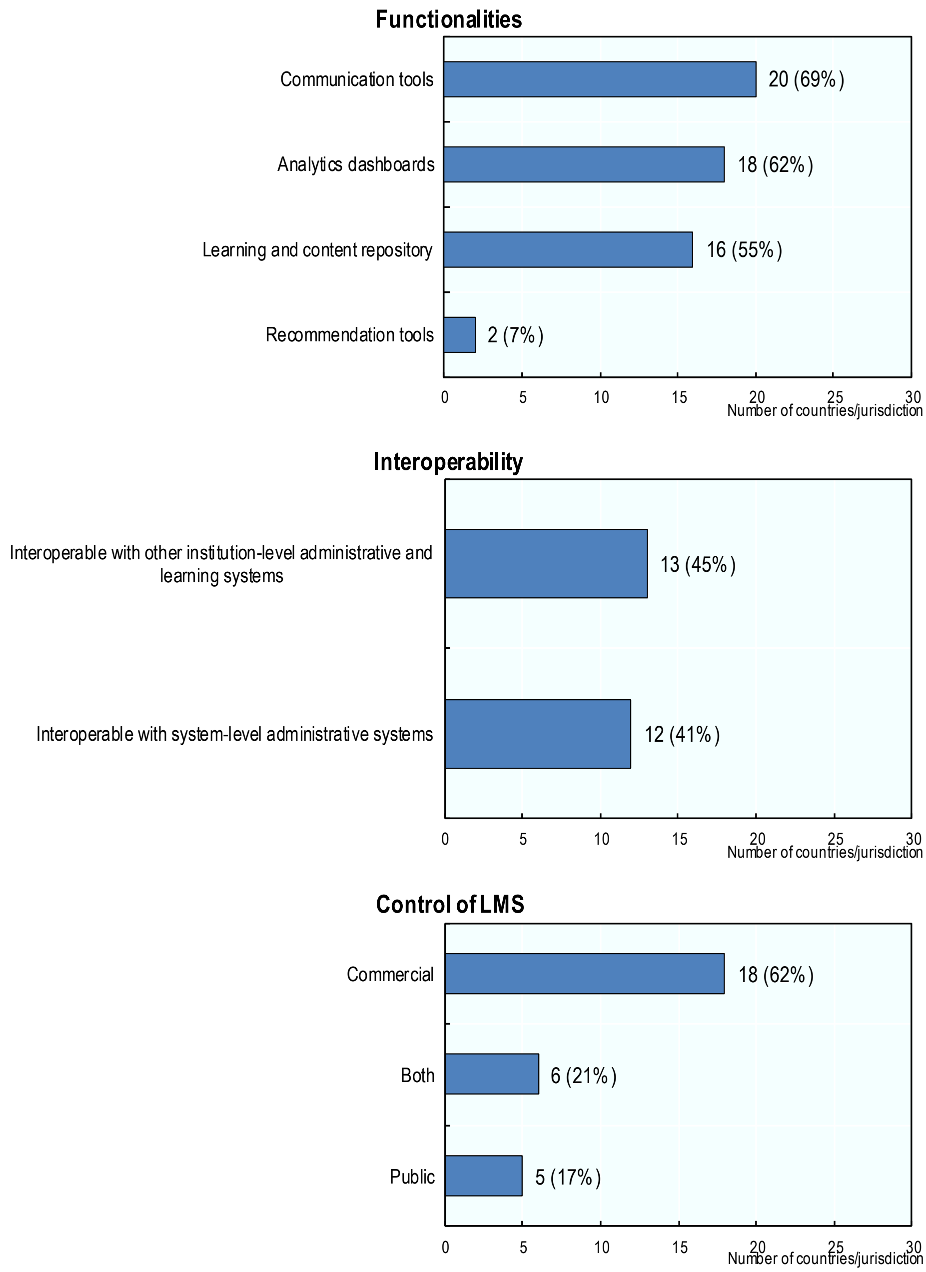
According to government officials, most schools within OECD countries use learning management systems, at all levels of school education. The COVID-19 pandemic has boosted their adoption and use. In some cases, schools use “free” systems such as Google Classroom.

In terms of functionalities, according to government officials, in addition to the functionalities of a local student information systems that allow to track students’ education, their timetable, their teachers, their grades, etc, a significant proportion have the capacity to handle learning content and can give students and teachers access to digital learning resources. In some cases, countries provide a different platform with digital learning resources – which assume the content management functionality of learning management systems. As a result, about two thirds of countries/jurisdictions estimate that their schools can use a school system to access digital learning content. As shown by Figure 3.2, most of the systems used by schools provide communication tools (with parents and students), analytics dashboards (presenting student data in a visual way).

Some learning management systems are interoperable with the system-wide student information system and can “push” the student information that they have to report in an automated way. Some are also interoperable with at least some other institution-level systems, although this is not always the case. Finally, almost no learning management system provides recommendation tools (and none had any AI embarked as of end of 2023).

Interoperability with system-level tools, and notably with central or national student information systems (and other relevant systems) is essential from an efficiency viewpoint (it avoids data re-entry and thus better quality and more timely transfers of data), but this is also what could enable the easier reuse of data collected at the jurisdiction or national level. When this is not the case, users will typically have to access state-level information from other digital tools, making it time-consuming for staff and limiting the number of use cases when system-level data can be re-used to inform school-level decisions. Interoperability with other institution-level systems matters for similar reasons, as all data that can improve the decision-making of teachers and school leaders are not necessarily collected by system-level digital tools. For example, if a learning digital tool about collects data about, say, executive functions of students in the schools, it is possible this could enable better uses of the language, history, arts, or mathematics learning tools used in the school (if any).

Figure 3.2. Common functionalities, control, and interoperability of learning management systems within countries (2024)



Note: In terms of "control", "both" means that countries/jurisdictions schools are provided by learning management systems (LMS) that were developed and owned publicly as well as commercial ones. All information was provided by government officials (and verified when possible). N=29.

StatLink https://stat.link/ytcfoq

Examples

A few countries provide their schools with a national learning management system. Often, this is because the system-level student information system provides schools with some of the functionalities of an institutional learning management system. This is for example the case in Luxembourg and Iceland (for upper secondary schools). In Iceland, the INNA system is both a learning management system for schools, allowing for student tracking, timetables, communication with students and parents, and handling of school fees, as well as a student information system for the government. In Luxembourg, Scolaria (primary education) and *Fichiers Eleves* (secondary education) are two student information systems that must be used by all public schools and, from a school perspective, have many of the common administrative functionalities of a learning management system: they help school staff manage student enrolments, enter and consult individual and class data, link students to their teachers or track student advancement and progression throughout the years. In Austria, the system-wide student information system Sokrates contains some functionality to manage the academic progress and attainment of students (e.g. recording attendance and grade, organising class activities, storing certificates in digital format), but other typical functionalities of learning management systems such as organising classes, providing learning resources and exercises to students, and communicating with students and parents are provided by two learning management systems, Eduvidual and LMS.at, which can be used on an opt-in basis. Türkiye provides all schools with a central learning management system, "*e-Okul*" ("e-School"), allowing schools to manage student registration, transfer procedures, grades, absenteeism, exam information, weekly course programme etc. Students use the web platform to have access to their grades, textbooks, daily study subjects, and school schedule.

Sometimes, countries provide two systems centrally, one focused on student tracking and administrative functionalities and one focuses on learning content management. For example, in Hungary, the e-Kréta platform publicly provided to primary and secondary institutions managed by school district centres has student tracking and content management functionalities. It is supplemented by a public content management system, the National Public Education Portal (NKP), enabling students and teachers to access protected contents or functionalities (learning materials, tests and other interactive activities and exercises, as well as interactive dashboards). Teachers can also utilise the platform to assign tasks or assessments to, and communicate with, students, and create their own content for use in their classrooms. Similarly, in Korea, the National Education Information System (NEIS), whose use is mandated in both public and private schools at all levels of education, combines the features of a student information system, a school administrative function system, a customer relationship management system, and a digital credential system. It helps teachers and school staff to manage student admission and enrolment, record the students' standardised test results and teacher-given grades, track student progress and learning trajectory throughout the school year, and transfer student qualifications to other educational institutions (including colleges and universities) in the country. Korea provides teachers and students with a content management platform with digital resources: EduNet T-Clear. The French Community of Belgium also provides their schools with two systems: the student information system (SIEL) can be used for some of the administrative functionalities of school administration, while publicly provided Moodle-based applications (Happi) can support them for content management, communication with students and parents (and include analytics dashboard). Schools can also choose to opt for another learning management solution if they so wish.

Another group of countries provides learning management systems publicly to schools, but at the sub-government level. This often follows the devolution of responsibilities within those countries (although this is not a necessity).

In the case of Spain, the autonomous regions are responsible for education (while the national ministry is responsible for the cities of Ceuta and Melilla): all regions provide a (more or less) customised version of Moodle, the free and open-source learning management system, which gives schools access to a learning and content repository, communication tools between students and teachers, and some rostering functionalities. In some regions those can be supplemented by commercial solutions.

In France, while the national student information systems (Onde for primary and SIECLE for secondary education) provide some of the functionalities of a learning management systems, those are typically provided by French sub-governmental authorities (regions, departments and municipalities, which are responsible for the infrastructure of upper secondary, secondary and primary schools, respectively). Most of them procure commercial tools (OpenENT, Open NEO, Classe numérique, etc.) but in some cases they are publicly developed (as is the case in Britany with the Toutatice ENT). They typically include communication tools, a repository of learning content, and are interoperable with other school-level administrative and learning systems, including some popular commercial tools that help manage teacher-given grades, timetable, attendance, sanctions, communication with parents, etc. In Japan, local governments (municipalities for primary and lower secondary education and prefectures for upper secondary education) procure commercial learning management systems for the school under their responsibility. These systems vary in detailed functions, but some of them are cloud-based and single-sign-on (SSO) enabled platforms, display analytic dashboards, provide tools for schools to communicate with students and parents. Some of them are also interoperable with institution-level administrative systems (such as student information systems, national/central assessment or examination platforms, etc.).

In France and Japan, the central ministries of education provide some technical specifications for these systems. For example, the French Ministry of Education publishes and continuously revises a "Blueprint for learning management systems (ENTs)", defining a common architecture, expected services, and setting technical standards for those tools.

In the Nordic and Baltic countries, municipalities typically provide schools under their authority with learning management systems, usually web-based commercial platforms that include, with variants, timetables, homework assignments, grades, evaluations and absences, information for students and parents, and communication tools. In some cases, the provision also follows the devolution of responsibilities: for example, in Iceland municipalities procure learning management systems for primary schools (whereas the state provides the above-mentioned system to upper secondary schools); in Denmark, municipalities procure learning management systems for primary and lower secondary schools, while upper secondary schools procure their management tools themselves. In Latvia and Lithuania, schools also have access to a customised version of Moodle (provided by the National Centre for Education in Latvia and the Kaunas University of Technology in Lithuania).

Finally, in about half of the countries for which we have information, schools themselves procure the learning management system of their choice. In Chile, the ministry has negotiated a contract for the use of the free version Google Classroom, which schools can choose to use or not at their discretion.

This is of course a crude picture as situations within countries can mix different scenarios. This is particularly the case in federal countries such as Canada or the United States where some provinces or states may provide their schools with a learning management system or leave it to districts. In New Brunswick (Canada), for example, the province procures a commercial learning management system for its schools, which are mandated to use it. In New York City (United States), the largest US school district, the department of education provides school with a learning management system that they can choose to use or not, and some schools procure directly other similar tools. Variety can be as significant in countries that are not federal, as many educational responsibilities follow "level of education" lines. For example, in Denmark, learning management systems in primary education tend to differ from those in upper secondary education and VET. In primary education, learning management systems mainly manage student administration, a functionality supplemented by access to Microsoft or Google education suites. In upper secondary education and VET, schools typically have a learning management system and student administrative system (e.g. Lectio) and also have access to Microsoft or Google education suites. Learning management systems contain some data about the student, but they are more a preparation tool for teachers and a place for the students to see and hand in assignments.

Table 3.1. Provision of learning management systems within countries (2024)

Public provision/procurement, control of system, interoperability and common functionalities

	Publicly provided learning management system at the central level	Publicly provided to schools at the sub-governmental level	Procured by schools/school networks themselves (possibly in addition to central provision)	Control of learning management system	Interoperable with system-level administrative systems	Interoperable with other institution-level administrative and learning systems	Communication tools	Analytics dashboards	Learning and content repository	Recommendation tools
Austria	✓			P/C			✓		✓	
Brazil				C				✓		
Canada		R		C				✓	✓	
Chile			✓	C			✓	✓		
Czech Republic			✓	C						
Denmark		M	✓	C	✓	✓	✓		✓	✓
Estonia		M		P/C	✓	✓	✓	✓	✓	
Finland		M		C	✓		✓		✓	
France		R		C		✓	✓		✓	
Hungary	✓			P/C	✓		✓	✓	✓	✓
Iceland	✓	M		P	✓	✓	✓	✓		
Ireland			✓	C	✓	✓	✓	✓	✓	
Italy			✓	C			✓	✓	✓	
Japan		M		C		✓	✓	✓	✓	
Korea	✓			P/C		✓	✓	✓	✓	
Latvia	✓		✓	C		✓	✓	✓		
Lithuania			✓	C	✓	✓	✓	✓	✓	
Luxembourg	✓			P	✓		✓	✓	✓	✓
Mexico				P	✓	✓		✓	✓	
Netherlands			✓	C						

	Publicly provided learning management system at the central level	Publicly provided to schools at the sub-governmental level	Procured by schools/school networks themselves (possibly in addition to central provision)	Control of learning management system	Interoperable with system-level administrative systems	Interoperable with other institution-level administrative and learning systems	Communication tools	Analytics dashboards	Learning and content repository	Recommendation tools
New Zealand			✓	C						
Slovenia	✓			P/C			✓		✓	
Spain		R		P	✓	✓	✓		✓	
Sweden		M	✓	C						
Türkiye	✓			P	✓	✓	✓	✓		
United States		D	✓	C				✓		
England (United Kingdom)			✓	C						
Flemish Comm. (Belgium)			✓	C	✓	✓	✓	✓		
French Comm. (Belgium)	✓		✓	P/C			✓	✓		
Total (29)	**9**	**10**	**14**		**12**	**13**	**20**	**18**	**16**	**2**

Note: In column 2, R indicates public provision by a sub-government level (state, region, province, prefecture); M refers to municipalities; and D to districts in the case of the United States. In column 4, P indicates the provision of a publicly-owned learning management system, C the procurement of a commercial product, and P/C the co-existence of public and commercial systems. N=29

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Customer Relationship Management Systems (communication)

Most learning management systems include some communication functionality, allowing schools to be in touch with students and parents. This does of course not imply that paper communication with parents (usually through a correspondence book) does not continue. In fact, these methods may remain the main way to communicate with parents in many countries, and they have their virtues. Some of the inconvenience with some of them is that they heavily rely on their children's willingness to share and properly write down the information (when it comes to homework). Some of this communication is now happening through digital tools, either as a supplement to paper-based information or as a substitute.

In the case of education, customer relationship management systems are software that facilitate the management of relations with different groups of contacts. In the case of schools, those are mainly students and parents; in higher education this would extend to alumni, funders, etc. In some cases, these systems are based on AI in order to customise how and when to address different types of stakeholders.

As noted above, schools often have access to several possibilities. In most countries, schools communicate with students through their learning management systems. Usually, if systems are mainly about content management, they will not allow to communicate with parents. This is the case in France, for example, where schools use other tools interoperable with the content management systems for that purpose.

In a few countries learning management systems do usually not have "communication" functionalities or at least are not used for this purpose. In Canada and in the United States, schools and teachers use separate dedicated communication tools to provide parents with information. In Canada, government officials relate it to their privacy laws. In the United States, most of the time teachers use freemium products for this function. It is possible that a dedicated tool may provide better functionalities or that there was some kind of path dependency in the functionalities of learning management systems.

Denmark also provides an interesting example where a communication tool different from a learning management system is widely used, the Aula platform, which was developed and is maintained by municipalities (through their joint IT organisation, KOMBIT). Aula has been progressively adopted by more than 1 700 primary schools (and over 4 000 day-care providers) and, as of 2024, operated as the primary customer relationship management system for hundreds of thousands of students, parents, and school staff at these levels of education. It emerges as a uniform system across institutions and municipalities. Its scalable, reliable, and robust data processing infrastructure meets all local authorities' data protection measures. With its massive uptake, it encouraged EdTech firms to raise their transparency standards to connect their products with Aula.

While digital communication with students and parents has become much more common, it is noteworthy that in about one third of the countries for which we have information, learning management systems do not typically have communication functionalities. Where the tools are provided by the central/jurisdictional government, they tend to do though.

Administrative functions systems

Most administrative tasks (e.g pay, budgeting, human resource management) are performed with digital tools, which are typically procured by the authority that employs teachers. Where teachers are central civil servants (e.g. Hungary or France), those tools are usually provided by the central government. Where schools are under the authority of a region, prefecture, municipality or another institution (district, school board, region), those will typically take care of these functions and provide digital tools to this effect. And when schools are independent, they will procure these solutions themselves. In all cases, this is a function that is largely digitised in all countries according to ministry officials.

For example, the management of school funding and school staff may involve the national government. In Italy, the Monitor440 app (accessible via the SIDI platform) supports both government offices and educational institutions with the planning, management, and monitoring of funding from the government. Government offices and educators use the POLIS Online Instances platform (*Presentazione On Line delle IStanze*) for a range of functions including processing applications for teacher and staff vacancies and transfers, registering staff in the ranking system, and collecting data about teachers' professional development and activities. Regional governments also share responsibilities for administrative and management processes, some of which may be carried out using local digital solutions.

In Korea, while the National Education Information System (NEIS) covers most system and school management functions, the ministry additionally provides a tool called K-EduFine, which combines formerly dispersed school administration and finance systems. Its use is mandated for budgeting, accounting, and several other administrative tasks, including the approval and transfer of official and work-related documents (e.g. manuals, information conferences, etc.), management of teacher and staff's schedule, etc. The local offices of education are legally required to use K-EduFine too, but for different purposes, such as allocating funding to schools. Türkiye also provides a suite of administrative functionalities to schools.

In Denmark, the ministry of education distributes state funding to institutions (except primary schools). The ministry does so by using a number of digital administrative systems (e.g. *CØSA, FagNavision, INDB*, etc.). The CØSA system is used for computing the central subsidies to the institutions, based on data from their administrative systems (educational operations, student enrolments and activities, etc.). These systems allow the payment of subsidy to be updated every quarter of a year. In Latvia, the central government allocates funding to schools through the *VIIS* system, and municipalities use it to pay salaries to teachers.[1]

A last class of administrative system relates to administrative documents. In Türkiye, the ministry provides a document management system (*Dijital Yönetim Sistemi*, or DYS) to facilitate the communication of administrative texts, such as employment and resignation letters, announcements, circulars, appointments, between the central government and local provinces or public schools. As part of a broader initiative to digitalise various parts of government, the electronic flow of administrative documents aims at easier and streamlined administrative and bureaucratic processes.

Facility management systems

Facility management systems allow schools to manage their facilities: school buildings, sport facilities, cafeterias, going beyond a "booking system". These tools are usually used for either sustainability purposes (minimise energy use), to analyse and better channel the use of the school buildings, etc. They can assist decision-making about when to make some spaces available to whom, etc. They remain very uncommon among schools according to ministry officials. They are virtually never provided by central authorities. Probably they are mainly interesting where school campuses are very large. While three countries reported to provide such system centrally to schools, they did not provide any evidence this would go beyond a room booking system.

Managing enrolments, credentials and preventing dropout

Early Warning System

In 2021, on average 10% of student enrolled in general secondary education programmes had not graduated and were no longer in education; the average was 23% for secondary vocational programmes (*Education at a Glance 2023*, B3.2 (OECD, 2023[6])). Dropout from school is high on the policy agenda in many OECD countries (and is also a burning higher education issue in some countries). In many low-income countries, keeping students (and notably girls) enrolled is also an issue.

Early warning systems are digital tools that use data available in usually (education system-wide) student information systems, learning management systems (or just other schools using the same early warning system) to predict early signs that specific students are at risk of dropping out of (usually upper secondary) school, based on a series of “early warning” indicators. Research indicates that early warning indicators can be very effective with as few as 3 observations, even though the most effective model so far included many more. Moreover, early warning indicators vary from place to place, influence by some local factors (Bowers, 2021[7]). Nonetheless, early warning systems need to have data beyond a single school, even if not many data per subject, in order to make more accurate predictions.

Early warning systems could be depicted both as an institutional and a system management tool: the information should be in the hands of teachers or school administrators so that they can intervene before dropout can take place; the more information the better to predict the risk, and thus ideally systems should us a greater amount of data than what is available within specific schools to establish their model (even though the number observations per person could be limited in number). Often, they use data from system-level student information systems to predict whether students might be at risk of dropping out from school, using AI quantitative techniques.

Those systems only have value if they manage to flag students at risk of dropping out that teachers had not identified as such (and they do it with a certain level of accuracy). In most cases those systems use AI techniques to reach their suggestions. As people who are “not in education, employment or training” (NEET) have become a policy issue and that school dropouts.

At the central level, Chili rolled out a governmental early warning system called SAT in 2020. It aims to predict and prevent school drop-out from 7-to-12th grade students enrolled in public or publicly subsidised schools. The system’s indicators are based on demographic, socio-economic, attendance, and performance data pulled from other interoperable systems such as the SIGE student information system. Based on an algorithm developed by the Chilean Ministry for Social Development and Family (MIDESOF) and transferred to the ministry of education for management and implementation, the system assigns a drop-out risk to every student. The use of the SAT is not yet widespread within the Chilean education system. A couple more countries have ongoing projects.

Hungary and Ireland also have developed early warning systems. To achieve its policy priority of reducing the ratio of early school leavers, Hungary’s Educational Authority operates an early warning system that leverages student data from classroom-based assessment performance, attendance, grade repetition and feeling of belonging for particularly vulnerable groups, refugees and asylum seekers. The information may lead to specific interventions, and notably include students in support programmes. Within its School Completion Programme (SCP), a central element of the Delivering Equality of Opportunity in Schools (DEIS) initiative operated by the Child and Family Agency (TUSLA) under the central government, Ireland leverages collected student data for flagging groups at risk for intervention given a comprehensive set of indicators.

In the United States, most districts use early warning systems of some kind. Some of them are based on AI-based diagnosis/predictions – which makes the United States the country that presumably has the most use and variety of AI-powered early warning systems in the OECD area.

A few countries are working on developing one. This is for example the case in Latvia. In Helsinki (Finland), an AI-based system, AI-HOKS, was piloted to explore how to support VET students to graduate (and limit their risks of dropping out). Its indicators are based on personal competence development plans, login and use of various tools and learning environments, weekly mobile questionnaires sent to students’ cell phones, and students’ feedback. As of 2024, the ambition was to provide, within a couple of years of use and the enlargement of the available datasets, an ethical learning analytics about drop-out.

Finally, while not informed by predictive analysis, several countries maintain “alert systems” (to distinguish them from early warning systems). This is still the majority of early warning systems in the United States.

Their data models are less ambitious and are mainly based on absenteeism. In many countries, and this would be true for low-income countries, one of the ambitions is to enforce compulsory education.

In Brazil, minimising school dropout and tracking and supporting individual students to meet the national plan policy goals is a top policy priority, and more or less advanced digital tools tracking students' attendance are present throughout all States, with some notable implementations such as the classroom journal (*Diário de Classe*) platform in São Paulo state, and a tracking system connected to SMS messages to parents' mobile phones implemented in the state of Goiás using principles of behavioural economics. A few platforms provided by the federal government and other stakeholders support educational institutions to ensure some social interventions follows students' observed absenteeism. Similarly, in Gujarat (India), the VSK student information system allows the state to follow in real time student absenteeism, which is acted upon after a certain time, ensuring that enrolments in schools for all is effective rather than procedural.

New Zealand is an example mixing the "alert" and "early warning" approaches: schools use the Attendance Service Application (ASA), a national student attendance system, to make absence referrals. Once a referral is generated, a local service provider will allocate it to an adviser for action to reduce student absenteeism. This data also feeds into a statistical predictive modelling tool used by the NZ Ministry of Social Development that essentially functions as an early warning system to identify at-risk youth and ensure they have access to the Youth Service for young people Not in Education, Employment or Training (NEET). In Korea, the student information system (NEIS) is also considered to operate as a support system to intervene when students appear at risk of dropping out of school.

Bringing these two types of early warning and alert systems together, five countries or jurisdictions (out of 29, so 17%) used them, including 3 (one in ten) leveraging advanced technology.

Student admission systems

Student admission (or enrolment) systems deal with different types of enrolments. In some cases, they are used to enrol a child in school through a digital system so that the information is immediately digitised. In other cases, digital tools are used for selective applications to schools and to support admission decisions. This may be when parents have some level of discretion in choosing the school of their children, when schools are selective, or when funding follows students. In most cases, digital student admission systems support school transitions, and notably the transition from lower secondary to upper secondary, and pathways towards vocational education and training and towards higher education. In all education systems, this is when choice becomes larger, and study tracks more numerous. Most centrally provided systems are used for admission in upper secondary education, vocational education and training and higher education.

Student admission systems are thus both an institutional management tool (schools can use them to register students or to select them) and a system management tool (systems support the matching between schools and students through a digital matching process). They aim to make the enrolment or selection process more efficient, and notably avoid duplications of data entry or loss of information.

Registration

Enrolling or registering a student in a school is still done in person and on a paper basis (or low teach means) in many countries, especially for lower levels of education. Admission systems tend to become digital in secondary education and beyond.

A few countries provide national tools to this effect though. Sometimes this is purely out of administrative efficiency, as is the case in Korea, Hungary, or Luxembourg, where a central system to manage student registration in school simplifies the enrolment procedures of students to their local school, school transfers, as well as the admission process to secondary schools. In Hungary, should parents wish to send their child in another school than the local one, the selection process of the preferred school also goes through the system.

In some Nordic and Baltic countries, municipalities sometimes also provide digital tools to that effect. In Denmark and Latvia, municipalities provide schools with digital systems to enrol or register students. In Iceland, where primary and lower secondary schools are operated by municipalities, parents fill in enrolment forms for their children directly on the websites of schools. In the United States, enrolments are devolved to school districts and schools, and US states do typically not provide school platforms to this effect. However, the process is typically done online, except in smaller districts. In most cases this is just a registration process. In Canada, enrolments are also done at the school level, and usually do not involve digital tools.

Selective application and admission

When parents or students exercise some level of "school choice" or when schools have criteria to admit students or can select them, central admission tools fulfil a more important function.

There are two types of matching systems. A first type of digital systems implements rigid algorithms based on regulatory criteria to indicate in which school students should or could study: usually distance between home and school, and sometimes academic performance. Those algorithms can include some equity or other types of dimensions and be used to influence the composition of the student body and make socio-economic background a decision criterion. They are also used to support parental choice (especially when there is no selection), notably by giving them information about schools or supporting their "strategic" decisions. From a system perspective, they help regulate an allocation process, especially when choices are numerous.

A few countries publicly provide central registration systems.

In Spain, student admission management systems are publicly provided by the relevant governing ministry to manage the allocation of students to schools. Parents use the system to apply for a place for their child in one or more schools. In Italy, since 2014, the ministry provides a centralised student admission management system called *Iscrizioni Online*: online enrolment is compulsory for all first-year students in state schools at primary and secondary levels (and optional for private schools). Parents can consult the *Scuola in Chiaro* website to find information about the schools they are interested. In this case, one rationale was to contribute to the general digital transformation of Italy, which was considered as lagging at the time.

In Chile, admission to all public or publicly subsidised private schools, at all education levels, goes through a school admission system managed by the central government (SAE). Families enrolling students have access to a broad variety of school information, such as available places and how competitive admission was in the previous year, teaching plan and curricula, performance information, and extracurricular activities. This information is pushed into the *SAE* system directly through interoperability with the SIGE student information system. Interoperability of the system with the Chilean Civil Registry systems allows the pre-filling of a significant part of their applications with key variables for the selection process such as socio-economic variables and the existence of enrolled siblings. Should there be more applications than available places, a selection process is performed through an algorithm taking several priorities defined by existing regulations into account (e.g. enrolled siblings, socio-economic disadvantage, children of school staff, etc.). The system randomly assigns any remaining school places.

In the French Community of Belgium, parents use a system called CIRI (*Commission Inter Réseaux des Inscriptions)* to enrol their children in secondary schools online: the admission depends on multiple legally established criteria (e.g. localisation, study record and envisioned study path, number and order of other students' applications). Parents can also visit a government website to check whether primary (and pre-primary) schools in their area have any free place left.

In France, regional academies (rather than the ministry of education) use the *Affelnet* platform (meaning "online student assignment") for applications and admission to upper secondary schools, whether general or vocational. Students (and parents) express their school and study preferences, and then criteria such as students' place of residence, academic achievements, and socio-economic background (based on the reception of a social scholarship) determine which upper secondary school they will attend. Each regional academy can calibrate the system (by allocating fewer or more weight to the different criteria). First piloted in the Paris region, the introduction of the system initially raised strong opposition, especially as it implemented new policies of social inclusion (Grenet, 2022[8]; Grenet, 2022[9]).

A second type of systems can be described as a manual "matching" system. They also essentially match students and institutions through an online application-admission process: students get information about education institutions, express their wishes, provide documentation; institutions use this information to select and rank applicants; and through a system of acceptance/rejection of offers students find a place in an institution. Admission systems based on the "matching" model are more common for the transition from high school to higher education or to vocational education and training. In this case there is usually no "automation" of decisions, although there are automatic verifications of credentials, etc.: these systems mainly focus on communication.

Admission to upper secondary education or to higher education is managed by such systems in an increasing number of countries.

In Denmark, the central government maintains a student admission management system, *Optagelse*, which students use to apply for upper secondary schools, vocational education and training (VET) programmes, and higher education institutions – which, in turn, use the system to review and select applications. Part of the system uses rule-based algorithms as part of the process. In Estonia, students apply to upper secondary institutions (gymnasiums and VET) and to higher education institutions via the Student Admission System (SAIS10). The platform provides information about the ranking of the educational institutions affiliated with the system, allows students to register for entrance exams and to receive notifications about the progress of their applications. SAIS uses existing data about the applicants from the Population Register, the Estonian Education Information System and the Examination Information System. Hence, students do not have to provide paper certificates and other documents with personal data to schools they apply for.

Brazil and France have relatively similar platforms to manage applications for higher education institutions. In Brazil, high school and VET student have to use the *SISU* platform to apply for a place in one of the country's public higher education institutions. Students list their preferred degrees, universities and institutions on the online platform, other selection variables (such as eligibility to affirmative action initiatives), and they are then selected based on their performance in the national university entrance exam (ENEM). The SISU platform is made available for admissions twice a year, reflecting academic semesters in Brazil, and students are invited to select and adapt their choices based on dynamically calculated student rankings and threshold grades for admission before the deadline. In France, upper secondary students submit their study wishes on the *Parcoursup* platform. Following a unique national calendar, students must use this platform to application for a (capped) number of the 21 000 higher education study tracks affiliated to the platform, receive advice and information on their study tracks, and receive/reject offers from institutions willing to enrol them. The platform relies on non-AI based algorithms to sort out applications based on certain criteria (e.g. academic achievement, rank within their class by subject, scholarship status, etc) and on an iterative matching process between institutions and their candidates. The platform in itself neither reviews nor ranks students' applications; it just allows post-secondary education institutions to rank applicants according to criteria they decide, before a final manual screening process.

Ireland also deals with its points-based higher education admission process through a unified digital platform maintained by the Central Admissions Office, a non-governmental not-for-profit organisation.

Credentialing tools

One of the areas for where the technology is ready lies in digital verifiable credentials and degrees. Smolenski (2021[10]) highlighted the efficiency benefits of using blockchain technology or other forms of unfalsifiable verification technology to ease the domestic and transnational transferability of credentials. Another reason relates to data protection and the management of digital credentials by their recipient. Finally, one of the hopes, which will still require some social changes, is that badges and micro-credentials will allow people to certify a variety of skills beyond those that are formally assessed. This can start in school, assuming students have access to the corresponding digital tools.

In most cases, diplomas and other qualifications are still managed through paper-based systems. According to our survey, 11 countries/jurisdictions out of 29 provide digital credentials to their school pupils. This uncovers different realities.

Some countries include a digital credential system in their education information system. This is for example the case in Korea, Mexico and the Netherlands. In Mexico, the education information system (SIGED) gives students access to their degrees. Similarly, in Korea and the Netherlands, students can access the education information systems (the DUO platform in the Netherlands and NEIS in Korea) to retrieve their degrees. As mentioned above regarding admission systems, Estonia allows for the verification and transmission of digital credentials within its digital infrastructure.

The Flemish Community of Belgium and France have dedicated platforms. In the Flemish Community of Belgium, the ministry of education's platform for digital credentials called LED records students' credentials (e.g. diplomas, proofs of experience) and makes them easily accessible online (and automatically when the credential is issued by a Flemish institution). People retrieve their credentials using their electronic identity card (eID), and can demonstrate their authenticity, for instance as a proof of eligibility for a study grant or they apply for an employment position. The platform is interoperable with other services of the Flemish government in education as well as non-education sectors' platforms (e.g. environment, social affairs). The LED credentials are aligned with Europass' "European Qualification Framework". In France, all national diplomas awarded since 2003 are digitised and accessible on a digital credential platform (diplome.gouv.fr) that allows to retrieve certified digital certificates and allows third parties to verify the authenticity of a person's degree through a digital key.

Italy has a different type of platforms that looks more like a student credential wallet. To better document students' experiences in school (e.g. their study paths, examinations), Italy's Digital Plan created a digital student profile for all students in secondary education. They use their student card, "IoStudio" ("I study"), to register their digital profile and are provide with opportunities to certify their skills, acquired both during and outside of school. This is an example of digital credential focused on "informal" credentials.

Some countries, such as Austria, are planning to implement a digital degree system.

Providing guidance about studies and careers

Careers/study guidance platform for students

Careers and study guidance are essential aspects of education systems, especially for students coming from families that are less equipped to navigate their country's education system and labour market opportunities. As students progress in their study paths, getting appropriate and, if possible, personally relevant information becomes key. The possible interactivity of digital technology and adaptive possibilities of AI make digital platforms particularly suited to provide a more personalised and up-to-date advice to students and families.

Most countries/jurisdictions maintain some digital study and careers guidance system for students: 23 out of the 29 countries/jurisdictions that answered the OECD survey on digital education infrastructure and governance, that is about 80%, reported the existence of national or jurisdictional platforms.

A few countries do usually not provide those platforms publicly. This is for example the case in Canada and the United States. Given their devolution of responsibilities, there are counter-examples though. For example, in Canada, the province of Manitoba has developed the public *Manitoba Career Prospects* platform to help students navigate the education system and find information about their future career. The platform also provides guidance to educators to help young people in Manitoba explore careers options and appropriate study paths in the province. Platforms for careers guidance are available in Brazil, but not universally provided for public students (except in vocational education and training). As of 2024, Sweden was in the process of developing of a nationwide careers and study guidance platform.

The absence of public platforms does not imply that students do not receive any guidance. In Canada, some provinces and territories report providing schools with access to commercial platforms tailored to students' province or territory of residence and providing them with a comprehensive study and careers planning programme from lower to post-secondary education, self-assessment tools to understand their skills and aspirations, information about eligibility criteria into selective tracks, province-specific graduation requirements, and more. While England maintains a national platform for all the population, English schools have the statutory duty to provide good careers guidance for their students themselves (and are supported by the ministry-funded Careers and Enterprise Company that provides an online resource to support schools and colleges to manage their careers programmes, plan careers activities, target support and collect student feedback systematically.

Countries (and jurisdictions) that do provide students with study and careers guidance tend to use three types of platforms.

Most platforms are simple, usually just a website including static information about the different study paths in the education system and some careers information. These websites often include self-assessment tools to help students and families make choices.

In Chile, the government makes resources available to students interested in continuing their studies in higher education through the *Mi Futuro* portal ("my future"): students can find information about higher education institutions, about admission criteria as well as on careers and future job prospects. This is typically the information available within the admission systems mentioned above. Czechia also provides a range of information and self-assessment tools through its National Pedagogical Institute (NPI). Similarly, In the French Community of Belgium, Brazil (for VET careers) and Ireland, the platforms are typically based on static information coupled with self-assessment tool(s). In New Zealand, the careers guidance platform provides information, tools and resources for secondary school students on choosing subjects or orienting career decisions after post-secondary education (and hosts a dedicated section on tools and resources for careers advisers in school). Similar guidance is provided by the *Meng Schoul* website in Luxembourg, the *UddannelsesGuiden* (Education Guide) website in Denmark, the ONISEP (*Office national d'information sur les enseignements et les professions*) website in France, or the HIFIVE and CareerNet platforms for VET guidance in Korea.

A second type of platforms includes recommendations based on students' experience, achievement, and interest: they allow for a more personalised and adaptive access to study and careers information. Their navigation is usually powered by (non-AI) algorithms. This is the case in Austria, where recommendations are adaptive to students' declared interests and experience. In the Flemish Community of Belgium, the Columbus platform is partially powered by non-AI algorithms.

A third type, generally geared towards vocational education and training, are platforms that not only provide information but also access to human advisers or ways to connect to particular apprenticeship or study positions. Their information may or may not be more personalised than a static website. In Korea, the ministry's *Ggoomgil* (Guidance for Dreaming Children) platform targeting all students enrolled in formal education provides them with opportunities to "try out" various careers and to reach out to physical "experience centres". In England, the National Careers Service maintains a digital careers advice platform, which provides people over the age of 13 with skills self-assessments and the possibility to receive advice from professional advisers. Similarly, in Lithuania, the AIKOS platform hosts counselling services and general information about VET-related professions, qualifications, study and training programmes, and about VET institutions and their admission rules. In Denmark, the *Lærepladsen* platform helps students find an apprenticeship in ministry-approved companies.

Careers guidance platform for teachers

Compared to study and careers guidance for students, teachers and other school staff are less often guided within or out of their current career. This type of advice can be useful to attract teachers in the profession, to help teachers navigate their possible options across a country or jurisdiction, or just to find out what other options they could have to change job if they so wish. Four countries/jurisdictions out of 29 (14%) provide a digital careers guidance aimed at teachers.

The French Community of Belgium and England provide similar platforms for teachers and aspiring teachers: *Pourquoi pas prof* (why not teacher?) in Belgium and *Get into Teaching* in England to inform them about career opportunities and requirements. In New Zealand, the Teaching Council of Aotearoa New Zealand provides a career website for teachers, with a range of information resources on certification and teaching practices. Korea also has the *Kkumgil* (career.net) platform for teachers.

Other types of digital systems or platforms

Countries were also asked to indicate whether they provide other kinds of digital software for system or institutional management purposes beyond those mentioned in our survey – and whether other types of systems were commonly procured by schools, sub-government or states. (Digital platforms of learning resources and tools, which are publicly provided at the national or jurisdictional level in a number of countries are presented in another chapter.) There is no common class of tools that were indicated under this category.

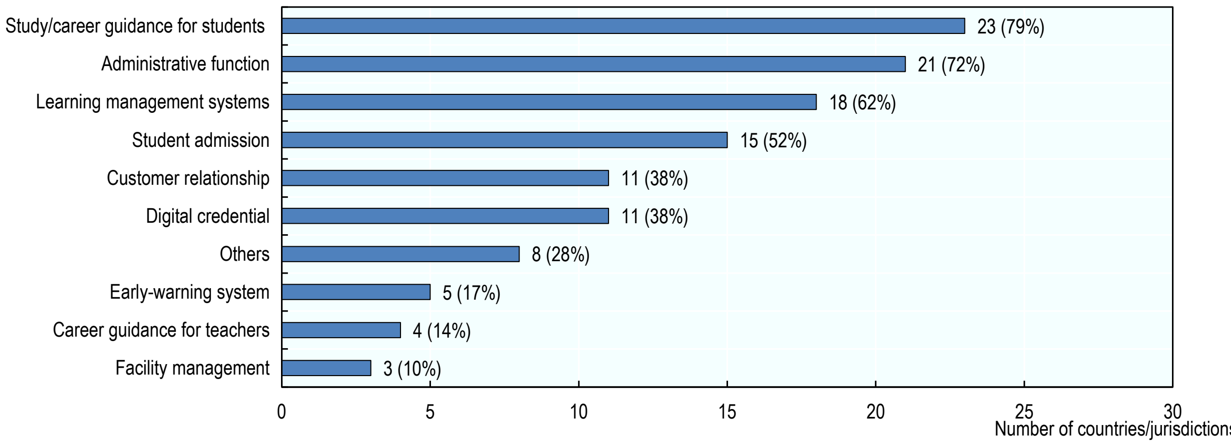
On the administrative legal side, Türkiye maintains centrally a document management system (*Dijital Yönetim Sistemi*, or DYS) to facilitate the communication of administrative texts between the central government and local provinces or public schools. As part of a broader e-government initiative, the platform aims to streamline administrative and bureaucratic processes by digitising the electronic flow of administrative and legal documents (such as governmental announcements, circulars, etc.). In many countries, these documents can be found on legal websites or the website of the education ministries/agencies.

Almost all countries/jurisdictions provide teachers with platforms for professional development services and resources. Those are not covered in this chapter. For example, in Luxembourg, the ministry of education provides the *Eformation* platform to make its training offer available to teachers, help teachers keep track of their mandatory training, and is used by the ministry to validate their training (through data exchange with their EPI system).

Summary and policy pointers for digital management tools

Beyond student information systems (EMIS), digital assessment platforms and knowledge/content platforms for teaching and learning resources, which are presented in other chapters, this overview showed the variety of countries' digital infrastructure for the management of their education system or their educational institutions. While some digital tools are publicly provided almost everywhere (e.g. learning management systems and online careers/study guidance), some remain rare (such as early warning systems, digital credentials or career guidance for teachers). Figure 3.3 and Table 3.2 summarise the state of the public provision of those tools, either at the central or sub-governmental levels.

Figure 3.3. System and institutional management systems publicly provided within countries (2024)



Note: The number shows how many countries/jurisdictions out of 29 provide those systems publicly at the governmental or sub-governmental levels in at least one education level. Where those are not provided, schools might procure them with public funds.

StatLink https://stat.link/4q2o8y

Table 3.2. Public provision of digital tools for system and institution management (2024)

	Learning management	Customer relationship management	Administrative function	Facility management	Student admission management	Digital credentials	Early-warning (dropout)	Study/careers guidance for students	Career guidance for teachers	Others
Austria	✓	✓	✓					✓		
Brazil			✓				✓	✓		✓
Canada	✓									
Chile		✓	✓		✓	✓	✓	✓		
Czech Republic			✓					✓		
Denmark	✓	✓			✓			✓		✓
Estonia	✓	✓	✓	✓	✓	✓		✓		
Finland	✓		✓		✓			✓		
France	✓		✓		✓	✓		✓		
Hungary	✓	✓	✓		✓		✓	✓		
Iceland	✓	✓	✓		✓	✓				
Ireland		✓	✓					✓		✓
Italy			✓		✓			✓		
Japan	✓									
Korea	✓	✓	✓		✓	✓	✓	✓	✓	
Latvia	✓		✓					✓		✓
Lithuania					✓			✓		
Luxembourg	✓	✓	✓	✓	✓	✓		✓		
Mexico			✓			✓		✓		
Netherlands					✓	✓				✓
New Zealand			✓				✓	✓	✓	✓
Slovenia	✓		✓		✓			✓		
Spain	✓	✓	✓		✓					
Sweden	✓							✓		
Türkiye	✓	✓	✓	✓		✓		✓		
United States	✓									✓
England (United Kingdom)								✓	✓	

	Learning management	Customer relationship management	Administrative function	Facility management	Student admission management	Digital credentials	Early-warning (dropout)	Study/careers guidance for students	Career guidance for teachers	Others
Flemish Comm (Belgium)			✓			✓		✓		
French Comm. (Belgium)	✓		✓		✓	✓		✓	✓	✓
Total	**18**	**11**	**21**	**3**	**15**	**11**	**5**	**23**	**4**	**8**

Note: The ticks indicate public provision of those digital tools by the national government or sub-national governments. An empty cell may correspond to procurement by schools themselves with public funds. Czechia got a new admission system approved that will be operational in 2024-25.

StatLink https://stat.link/vjftx9

Monitoring usage

Before discussing the opportunities and challenges of a strong digital infrastructure of institution and system management tools, one should note that the availability of digital tools does not equate that they are being used. This is particularly true for teaching and learning resources, but this sometimes extends to the tools discussed in this chapter. For example, while public learning management systems were already available before the COVID-19 pandemic, in many cases this is when their content management functionalities were used.

The use of some of the tools is mandated and thus not really for discussion: this is the case for digital systems geared towards administrative operations and for many admission or digital credential systems. This just means that all schools in the respondent countries manage the payment of their teachers digitally, for example. Where enrolment/registration systems are provided, they must be used. In the case of admission systems, they are mandatory when it comes to “school choice” in formal education, but can just concern a sub-group of institutions affiliated to the system when dealing with applications to higher education or vocational education and training institutions. Depending on the nature of the platforms, they can be used more or less. Where they deliver or verify official degrees, one can expect systematic usage (unless they duplicate paper degrees).

For all other digital tools covered in this chapter, use is optional – and, when devolved to sub-governmental levels, so is their provision. In some cases, sub-governments may mandate their uses. In the absence of regular statistical monitoring of their usage by countries (or international comparative surveys), there is no reliable information about the actual usage of these tools. Our survey (and interviews) included a question asking a best educated guess about the use of these different digital tools by schools in their system (for each level of education). Apart from the administration function systems, which were reported as universally used, the reported levels of digitalisation should be interpreted with caution – despite the digital game changer that the COVID-19 pandemic was. For this reason, they are not reported here. However, even though one can discuss the extent to which these tools are used, which probably varies by level of education, the responses can be expressed as rough bands of usage across countries: the widespread or common digital tools are administrative functions systems, learning management systems, digital communication tools with parents (either part of the learning management system or separate), digital registration/admissions and study/careers guidance for students. The use of digital credential platforms is moderate, while the use of facility management systems, early warning systems and career guidance for teachers is rare. This is largely aligned with the public provision pattern. Hopefully domestic and comparative studies will cast light on the real prevalence and use of these digital tools within schools.

Taking advantage of advanced technology (AI)

While many of the discussions focus on automation and the use of AI within education systems, it is noteworthy that none of the digital tools mentioned in this chapter us AI-based algorithms – except for some early warning systems in the United States or in pilot phase in some other countries. Some systems use criterion-based algorithms, notably in application/admission systems, or other types of advanced technology, notably for verifiable credentials, but overall, as of 2024, there was no algorithm based on machine learning or AI to report across countries. There were also very little diagnosis tools, recommendation tools and virtually no automated decision-making tools (with only the admission management tools getting somewhat close).

Harnessing the possibilities of hard-coded and machine-learning AI to grasp the affordances of current technology may be one of the upcoming opportunities (and challenges) of countries. For example, even though most learning management systems provide dashboards to help administrators and teachers to make sense of the collected data, those are relatively simple data visualisations. Very few include predictive or analytical models or make recommendations, for example about what teachers should consider using as a learning resource given the characteristics of their class, who they could contact to share notes, how school principals and teachers should form classes, how they could join efforts with schools or classes having similar issues, interests, or strengths, etc. The main interactive element of study/careers platforms lies in (personality) self-assessment tools that help identify the types of careers a student might be interested in. Given the quantity of data and recorded opinions education systems have about each student, probably technology could help to make the guidance more personalised and relevant.

While many observers focus their attention on the potential dangers of AI in education, our overview of countries' digital infrastructure for system-level and institution-level applications shows that the latest possibilities of technology are largely untapped. Few countries seem to be exploring use cases that would make those possibilities effective for students and other education stakeholders.

Reflecting on public provision or procurement models

There are different models to give access to schools, students and their families, and teachers, a digital infrastructure. Some countries provide the tools publicly at the central level; others delegate the public provision to a sublevel of government responsible for a group of schools; others provide public funds to schools and let them procure the tools they need. A second decision is to develop/own public tools or to just license them from the for-profit education technology sector. Each of these models have their advantages and disadvantage, as presented in Table 3.3.

Table 3.3. Advantages and disadvantages of different models of public provision or procurement

	Advantages	Disadvantages
Central provision	• Equal access across schools; • Interoperability with system-level tools; • High (price) negotiation power; • Availability of technical competences	• Risk of irrelevance to some contexts and no use (unless mandated) • Possible lack of diversity of providers and products
Sub-governmental provision	• Close to local situation and school needs; • Allows for the development of a variety of solutions (and competition); • Medium (price) negotiation power; • Availability of technical competences	• Inequal access across sub-governmental authorities; • Risk of non-interoperability
School procurement	• Meets school needs; • Allows school to build their own consistent digital ecosystem	• Possible loss of economies of scale; • Possible lack of technical competence
Public ownership	• Customisation of tools to government/system needs; • Strong data protection and privacy; • Possibilities of research for policy improvement	• Less in-house design/development competence; • Need of continuous investment to avoid rapid obsolescence; • Lower incentives for innovation and improvement (quality and effectiveness)
Public procurement	• Allows to benefit from market competition and choice; • Beneficial to EdTech market dynamics	• Risk of vendor lock-in; • Possible redundancy of functionalities across tools; • Lower access to and learning from data collected by digital tools

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In most countries, the models are based on the usual devolution of responsibilities within the education system, often justified by legal reasons and sometimes by habit. This need not be the case. For some digital tools, countries may consider using a different model than the one they are used to. It depends on many factors and the objectives that they want to meet: equality of access; quality of the education technology offer; further integrating the system; avoiding the purchase of inefficient tools, etc. This may require an amendment to their legislation or their habits.

A minimal public infrastructure?

Some countries have a dual model whereby they publicly provide a central or jurisdictional tool and allow for the purchase of similar tool with public funds by sub-governmental authorities or schools. This is an interesting model: while it could be seen as duplicating efforts and a waste of public resources, it does have the advantage of providing all schools with a free-of-charge “minimal” digital infrastructure. It also has the advantages of providing schools with some choice, and of building some level of technology competency within public ministries/agencies. In some cases, schools and stakeholders do not use these public tools because they do not know about their existence, because they are not as user-friendly as commercial tools, or just because they prefer to continue to use tools they are already used to. Countries should monitor and understand the reasons for the use and non-use of these public tools and their actual role in countries’ education policy and digital strategy.

In light of the recent COVID-19 pandemic, countries should consider what they expect schools, teachers and students to have as a minimal digital infrastructure. According to government officials, the pandemic led to a boost in the adoption of learning management systems by schools. Public authorities have also increased their direct provision of digital tools. While a devolved digital infrastructure has many advantages, a resilient infrastructure is also one that can be quickly expanded and that ensures all schools, students and teachers in a country will have access to at least a minimal sufficient amount of learning resources – whose delivery requires a minimal amount of digital tools in schools.

From efficient management to effective and strategic uses of the ecosystem towards a digital transformation

As noted above, a key element in any digital ecosystem lies in a robust longitudinal student information system (or EMIS). The main reason is that centralising some important data about one’s system allows to feed it back to other platforms when relevant. At the institution level, learning management systems are the equivalent to student information systems, and therefore arguably one of the key tools for institutions. A key feature is for learning management systems to be able to seamlessly push information to student information systems, which was possible in about half of the countries for which we have information. However, it is also important for schools to receive (or pull) system-level information to make their learning management system more powerful.

One way to describe would be to move from efficiency to effectiveness, from targeting local average efficiency to system-level learning to have more effective implementation of countries’ policy goals.

Cost-efficiency and increased productivity is a desired benefit of the digitalisation of administrative processes, in the education sector as in other sectors. Many of countries’ efforts so far can be described as an effort to digitise the operational management of many processes in education. The management approach tends to focus on some specific task and see if it can be digitised and semi-automated, thus involving less human intervention than previous processes.

Digital credentials require fewer human resources to address graduates’ delivery requests or third parties’ verification requests than paper credentials. They also require less waiting time for users requesting the degree or its verification: except when there is a problem and a human intervention is needed, the retrieving and verification processes are automated. Moreover, fraud becomes much more difficult. Registering a student to a school digitally has similar benefits: it increases the speed and accuracy of the process; moreover, the registration may trigger several administrative actions automatically and save time for school staff. Sometimes the information can be pre-filled from other official databases and maximise time-efficiency and accuracy.

This piecemeal managerial or operational approach to digitisation is important and should be continued, but alone it will not lead to a digital *transformation*. A digital transformation comes from reaping the benefits of the whole data and digital ecosystem and invent new processes to achieve identified policy goals. From a mere local perspective, the digitisation process is not always more efficient, which may explain the lack of use of some digital tools, at least prior to the COVID-19 pandemic. The true value of digitising some processes at the local level may be to provide possibilities of learning and of interventions to the whole system. This should be clearly communicated to stakeholders.

For example, in a rural school with a handful of students and classes, there may be no perceived need for the administrative functions of a learning management system and just getting on with informal (or paper) management may be less time-consuming and as effective. What is missed here is that the data provided to the overall ecosystem by all these local schools can help improve the system. In Gujarat (India) for example, the use of the VSK student information system (or EMIS), which brings together a variety of data, allowed policy makers to diagnose shortcomings of educational provision in rural areas and to design a new policy intervention (e.g. the creation of excellence boarding schools).

Similarly, a region or neighbourhood with very little school dropout may not see the need for an early warning system – or just collecting data to design early warning indicators. This tends to be the case for low occurrence phenomena. This does not imply that their information cannot help reduce dropout elsewhere – and even in the few cases when they may occur locally. Several countries have used their data infrastructure to enforce attendance (in line with their compulsory education policy) or just support it (in line with their policies to prevent school dropout).

One challenge in designing or thinking about a digital education ecosystem is the multiplicity of digital tools: on the positive side, this can be depicted as welcome diversity and emulation; on the negative side, this can be seen as fragmentation. Fragmentation is not always a problem though, nor destiny. Interoperability of at least certain digital tools, that is, their ability to "share information" seamlessly (or with very little effort) is a condition to a digital transformation (and, in many cases, to efficiency). But interoperability has to come with imagination and strategic vision. For example, most countries favour the creation of "professional learning communities" among teachers. In secondary education, depending on the subject(s) they teach and the size of the school, establishing such professional learning communities may be difficult. Could technology and the information collected in different parts of the system help create meaningful groups of teachers and harness the power of technology to achieve this declared policy goal? A key question when providing or supporting the provision of a digital infrastructure is thus: given some policy objectives, how can the digital infrastructure be mobilised to create new education processes, and what are the digital tools that schools, teachers and students should have available for this purpose?

References

Bowers, A. (2021), "Early warning systems and indicators of dropping out of upper secondary school: the emerging role of digital technologies", in *OECD Digital Education Outlook 2021: Pushing the Frontiers with Artificial Intelligence, Blockchain and Robots*, OECD Publishing, Paris, https://doi.org/10.1787/c8e57e15-en. [7]

Fragoso, T. (2023), "Hardware: the provision of connectivity and digital devices", in *OECD Digital Education Outlook 2023. Towards an Effective Digital Education Ecosystem*, OECD Publishing, https://doi.org/10.1787/c74f03de-en. [4]

Grenet, J. (2022), *La transparence et l'obstacle: Principes et enjeux des algorithmes d'appariement scolaire*, Presses de Sciences Po. [8]

Grenet, J. (2022), *Les algorithmes d'affectation dans le système éducatif français*, Presses de Sciences Po. [9]

OECD (2023), *Country Digital Education Ecosystems and Governance. A companion to Digital Education Outlook 2023*, OECD Publishing, https://doi.org/10.1787/906134d4-en. [5]

OECD (2023), *Education at a Glance 2023: OECD Indicators*, OECD Publishing, Paris, https://doi.org/10.1787/e13bef63-en. [6]

Smolenski, N. (2021), "Blockchain for Education: A New Credentialing Ecosystem", in *OECD Digital Education Outlook 2021: Pushing the Frontiers with Artificial Intelligence, Blockchain and Robots*, OECD Publishing, Paris, https://doi.org/10.1787/6893d95a-en. [10]

Vidal, Q. (2023), "Digital assessment", in *OECD Digital Education Outlook. Towards an Effective Digital Education Ecosystem*, OECD Publishing, https://doi.org/10.1787/c74f03de-en. [2]

Vincent-Lancrin, S. and C. González-Sancho (2023), "Education and student information systems", in *OECD Digital Education Outlook 2023. Towards an Effective Digital Education Ecosystem*, OECD Publishing, https://doi.org/10.1787/c74f03de-en. [1]

Yu, J., Q. Vidal and S. Vincent-Lancrin (2023), "Digital teaching and learning resources", in *OECD Digital Education Outlook 2023. Towards an Effective Digital Education Ecosystem*, OECD Publishing, https://doi.org/10.1787/c74f03de-en. [3]

Note

[1] More about the Taximeter system: The taximeter system | Ministry of Children and Education (uvm.dk).

4 Digital assessment

Quentin Vidal, OECD

This chapter provides an overview of the digitalisation of national and central assessments across OECD countries and jurisdictions. It explores the opportunities that new technology and smart data offer to transform assessment practices and compares it with what countries and jurisdictions effectively leverage while digitalising their assessment. Balancing those tensions, the chapter offers insights as to why most system-wide student evaluations are now digitised while high-stakes examinations remain predominantly paper-based. Finally, it makes suggestions that policy makers may consider to move towards an effective digital assessment ecosystem.

Introduction

In the ever-evolving landscape of education, the effective assessment of student learning outcomes, and the continuous evaluation of education systems' capacity to provide quality education and ensure equitable opportunities for all, play a pivotal role in shaping educational policies and practices.

At the class and individual levels, two main types of student assessment coexist: formative assessments and summative assessments. Conducting formative assessments is the ongoing process of assessing and providing feedback on student learning throughout their learning journey. Formative assessment aims to monitor students' progress to provide opportunities for improvement and guide instructional decisions to enhance learning outcomes. In countries and jurisdictions that have incorporated formative assessment practices into the classrooms, teachers typically use quizzes, assignments, projects, or class discussions to gauge student progress. Administering summative assessments, on the other hand, is measuring students' overall learning achievements to determine the level of mastery of specific learning objectives at the end of a specific period of learning. Summative assessments can take the form of final exams or end-of-year assessments, but include all sorts of assessments, including teacher-given assessments, that are administered primarily to assess student learning. Summative assessments are the focus of this chapter.

At the level of an education system as a whole, countries and jurisdictions typically resort to summative assessments to assess key student learning outcomes and the quality and equity of education systems. At the central or jurisdictional level, assessments may take the form of student *examinations* and *evaluations*. *Examinations* are often administered at the end of primary or secondary education. Exams carry high stakes for students as they determine their progression to higher levels of education or provide them with a qualification before they enter the labour market. But system-wide assessment may also consist in standardised student *evaluations*, which are assessments designed to measure entire cohorts of students' skills in specific key subjects, such as reading, mathematics or science. Countries and jurisdictions may administer those evaluations in a census-based approach, where all students of a given cohorts are assessed on the same subjects; or using probability sampling, where only a representative sample of students are evaluated in each subject.

Digitalisation presents both opportunities and challenges for the administration of exams and evaluation. Digitised (or computer-based) assessments offer adaptivity, enabling the tailoring of assessment questions' difficulty based on responses for more accurate skill measurement (see Box 4.1). They may assess new or traditional skills through varied means. Immediate feedback empowers students to recognise content areas that they master from those where they struggle, enhancing and paving the way for more granular, personalised learning. Learning analytics, generated from the analysis of log data, offer insights that extend beyond the final outcomes of the assessment, allowing to understand how students reflect on their assessment and not only whether they get the right answer (OECD, 2021[1]). Digital assessments also provide flexibility and accessibility, accommodating diverse learning situations and notably helped ensure assessment continuity during the COVID-19 crisis and worldwide school closures (OECD, 2020[2]). Finally, in some cases they can prove to be cost-efficient, with reduced expenses due to automation (of parts of the grading process for instance), replication, and lowered printing and distribution costs – although experience suggests that building valid, reliable and fair digital assessments is not necessarily cost-effective to measure simple constructs (Buckley et al., 2021[3]).

However, transitioning to digital assessments presents challenges for countries and jurisdictions. Reliable technology infrastructure, data privacy, and security measures, along with disparities in access in face of digital divides, create obstacles (see (Fragoso, 2023[4])). Furthermore, designing valid and reliable digital assessment items aligned with educational goals is a complex process, let alone when featured in high-stakes examinations – which further demands innovative solutions to address concerns over cheating. Transitioning to digital assessments thus requires a solid digital infrastructure, inclusive of the humans who comprise it. Teacher training and professional development are essential for good design and effective implementation (see (Foster, 2023[5])).

Box 4.1. About the design and implementation of digital student assessments – a review of the literature

Digital assessments have advantages and disadvantages. Some of the most obvious advantages include the possibility of rapidly marking them and providing feedback, reducing human biases and errors, and the fact that they, at least partially, address teachers' workload (Leaton Gray and Kucirkova, 2021[6]). Other more technical advantages include the possibility of using adaptive testing or using sophisticated trackers of academic progress across an extended period of time (Veldkamp and Sluijter, 2019[7]). On the other hand, there are challenges to consider, such as how data should be collected, used and stored (Timmis et al., 2015[8]). Ethical questions may also emerge in relation to inequalities, as it cannot be assumed that all teachers and students have the necessary skills to use technological devices/software. This may impact on students' assessment results (Wyatt-Smith, Lingard and Heck, 2021[9]). Other challenges arise with specific technology-enhanced assessments. For example, assessments marked by algorithms may be less transparent and hard to verify, particularly with machine learning (e.g. essay marking) (Veldkamp and Sluijter, 2019[7]).

In its review of the challenges of computer-based testing in England (United Kingdom), Ofqual studied its introduction in Finland, Israel, and New Zealand (Ofqual, 2020[10]). The authors found that successful implementation required a strong "risk appetite" – recognition and acceptance by stakeholders that some things would go wrong and an understanding there would be some "learning by doing". Each of the countries and jurisdictions took a different approach to implementation. For example, New Zealand took a gradual, voluntary approach. This resulted in a longer timeline for introduction but enabled public perception to change as the adoption grew to ensure positive user perception prior to use. Technical glitches were easily overcome by the ability to revert to paper-based testing. The downside of this approach was the dual running of paper and computer-based assessments, which risks to give an unfair advantage or disadvantage to groups of students. Biases related to the method of assessment delivery could ultimately hinder performance comparisons (McClelland and Cuevas, 2020[11]) ; (Kolen and Brennan, 2014[12]); (Sandene et al., 2005[13]). Another example is provided by Australia, which underwent a broad research and development programme before and during the transition of its NAPLAN to a computer-based delivery.

Adaptive testing is efficient, as students do not waste time and effort on questions that are too hard or too easy for them. As candidates only answer items that are paired to their ability, the assessment length can be reduced in comparison to linear assessment forms, and the assessment administration can, if desired, be more flexible in terms of time as a result of individualised testing (Veldkamp and Sluijter, 2019[7]). At the same time, some international evidence shows that test-takers report feeling discouraged after taking a computer-based adaptive test, and this feeling can reduce learning self-efficacy and motivation (Kimura, 2017[14]). In addition, adaptive assessments require a large bank of test questions, which increases development costs (OECD, 2013[15]). Recent breakthrough in generative text AI may alleviate some of these costs in the future. Furthermore, it may be challenging to explain to students and their parents why test experiences differ between students, as well as how the test results should be interpreted (Somers, 2021[16]).

Source: Extracted from (OECD, 2023[17]), "Strengthening the design and implementation of the standardised student assessment reform of the Flemish Community of Belgium", OECD Education Policy Perspectives, No. 72, OECD Publishing, Paris, https://doi.org/10.1787/85250f4c-en.

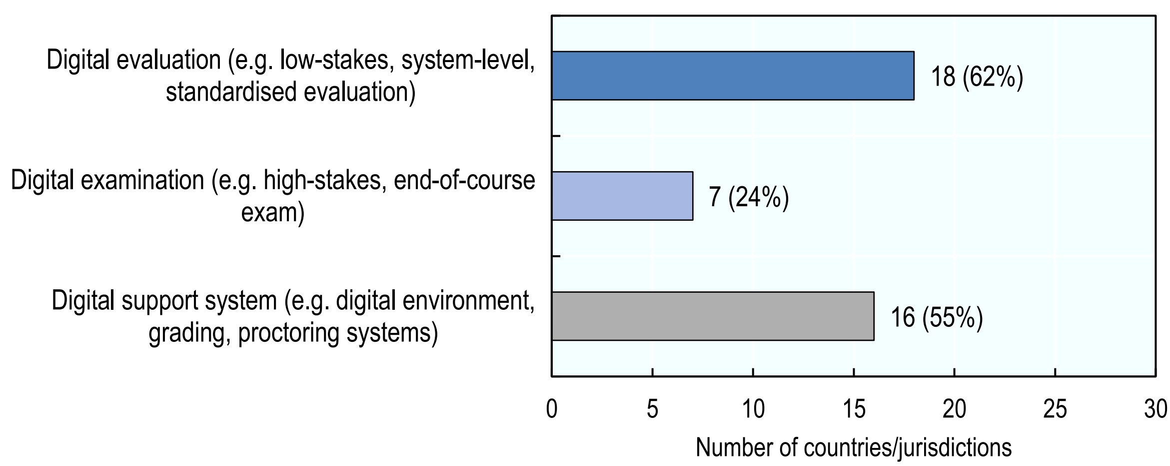
This chapter provides an overview of the increasing use of digital tools to administer various types of assessments. The first section looks at the digitalisation of standardised student evaluations, examining the motivations that drive countries and jurisdictions in the transition from paper-based to computer-based administration while addressing its challenges. The next section focuses on digital (high stakes) student examinations, suggesting why they are less often taken digitally than student evaluations. Finally, the chapter explores the landscape of digital support systems that countries and jurisdictions have developed to support the administration, grading and processing of various assessments, whether digital or not. The chapter concludes with a reflection on the trends in the digitalisation of assessments, taking stock of the (so far limited) transformation that digitalisation has brought about, and envisioning what countries may do next to reap the benefits of the innovative affordances allowed by digital assessments.

A state of the art

Our comparative analysis covers 29 countries and jurisdictions. All OECD countries and jurisdictions were asked to answer a survey on digital education and infrastructure. The answers to the questionnaires were validated through meetings with the responding team and expanded by desk research to describe countries' digital education infrastructure and governance (see the related publication (OECD, 2023[18])).

Most of the countries and jurisdictions that have taken part in our data collection have developed digital tools to assess students and/or to support their assessment (Figure 4.1). Out of 29 countries and jurisdictions, 18 (or about two-third) administer system-level standardised student evaluations that are fully or partially taken digitally, among which two are federal countries where all or most of their states or regional authorities conduct student evaluations at their level. Seven have fully or partly digitised some of their high-stakes examinations; and 16 have developed digital tools to support the administration of assessments, digital or not.

Figure 4.1. Number of countries and jurisdictions with national/central digital assessments (2024)



Note: N=29.

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Digitalisation of standardised student evaluation

Standardised evaluations of education systems are typically the first type of assessment that countries and jurisdictions have digitised, and the most common type of (publicly administered) digitised assessment as of 2024. Student evaluations are usually relatively short and generally made of closed-answer questions to facilitate their systemic completion and grading at the jurisdictional level. Moreover, they are cyclical and fully or partially repeated over years to assess trends in a short range of key student achievements: literacy (in the national language(s)), numeracy, and, in some cases (e.g., Italy, Norway or Sweden), in other subjects such as English as a foreign language. Finally, standardised evaluations carry low (or no) stakes for individual students (although they may have one for schools and their staff): results are only analysed at the larger unit of the class, the school, or the jurisdiction as a whole. For those reasons, standardised evaluations appear easier to digitise than traditional exams.

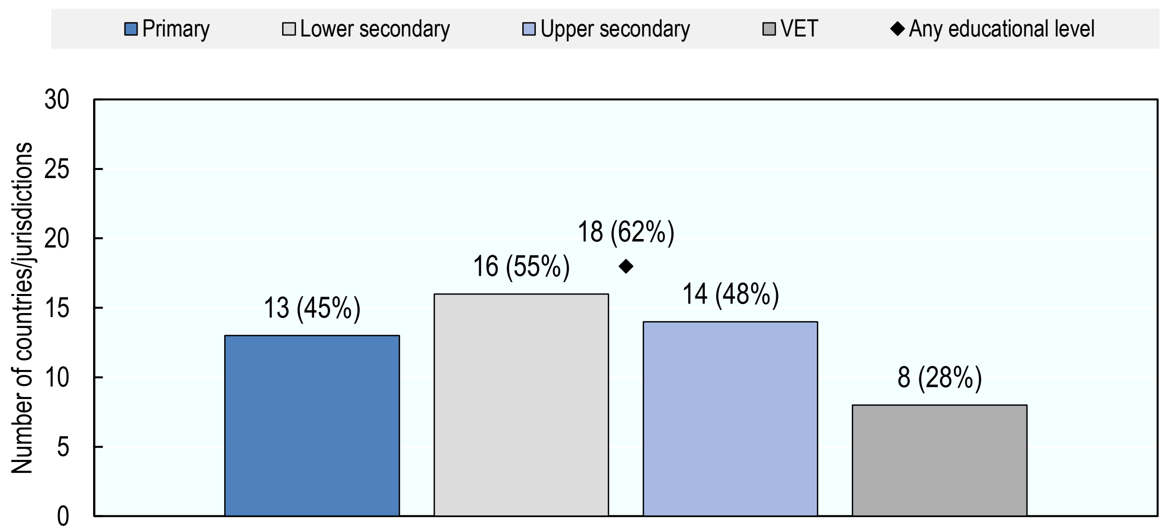
Country coverage and main characteristics

Over the last two decades, more and more education systems have deployed their own standardised student evaluation. Across the OECD, most countries, including countries where the education governance is largely decentralised to regional (e.g., federal countries) or local authorities (e.g., Nordic countries), administer such standardised student evaluation nationally.

Data from OECD *Education at a Glance 2023* (EAG) show that national/central evaluation are more prevalent at primary and lower secondary levels than at upper secondary level (OECD, 2023[19]). About four-fifths of the 39 countries and jurisdictions participating in EAG with data available conduct at least one national/central evaluation on students at primary level (33 countries and jurisdictions). The share is similar for lower secondary level (32 countries and jurisdictions). In upper secondary education, less than two-fifths (14 countries and jurisdictions) conduct such evaluations. National/central evaluations take place in different grades throughout primary and secondary levels. They are commonly conducted six and nine years after the start of primary education (in 19 countries and other participants for each grade). Before 2023, information on the national/central evaluations put in place by countries were last collected by EAG in 2015. Both rounds of the survey collected data on the use of digital technology in national/central evaluations in three subject areas: reading, writing and literature; mathematics; and natural sciences. Between 2015 and 2023, the numbers of countries and jurisdictions using digital technology in their national/central evaluations in at least one level of education almost tripled, from 8 to 21. The shift to digital testing was notable particularly in the last five years (e.g. Canada and France since 2019, and Hungary and Korea since 2022). Several systems are planning to also have digitised evaluations in the coming years (e.g. the French Community of Belgium, Germany).

Unless otherwise stated, the rest of this chapter will focus on the 29 countries and jurisdictions that participated in the specific data collection conducted for the Digital Education Outlook 2023.

Figure 4.2. Number of countries and jurisdictions with national/central digital student evaluation (2024)



Note: N=29.

StatLink https://stat.link/96lorp

Out of 29 education systems for which we have comparative information, 24 have national/central student evaluations. Among them, 18 are partly or fully digitised (about two-thirds of all surveyed countries and jurisdictions, and three-quarters of those with standardised evaluations), as shown on Figure 4.2. The left-hand part of Table 4.1 below synthetises information on national and central student evaluations.

Table 4.1. National/central digital assessments: availability and characteristics of student evaluations and examinations (2024)

	National/central student evaluation			National/central student examination		Assessments results stored in (or easily retrieved from) a student information system
	Digitised form	Levels of education where digitised	Name of the digitised assessment(s)	Digitised form	Levels of education where digitised	
Austria	✓	Lower secondary	Individual competence measurement PLUS	X		
Brazil	X					
Canada	✓	Primary*, Secondary*, VET*	Pan-Canadian Assessment Program (PCAP) + Provinces own systems	X		✓
Chile	X			X		✓
Czechia	✓	Primary, Secondary	Survey on educational results, survey on level of literacies	X		
Denmark[1]	✓+	Primary, Secondary	Folkeskolen's National Skills Test	✓	Primary, Secondary	✓
Estonia	✓	Primary, Secondary, VET	Standard-determining tests	✓	Secondary, VET	✓
Finland	✓	Primary, Secondary, VET	FINEEC's longitudinal assessment of learning outcomes	✓	Upper secondary	
France	✓+	Secondary	Cèdre, Socle (CUT) + Évaluation de positionnement en début de 2nde	X		
Hungary	✓	Primary, Secondary, VET	National Assessment of Basic Competences	X		✓
Iceland						✓
Ireland	✓	Primary, VET	Standardised testing in primary schools + Drumcondra (optional)	X		
Italy	✓	Secondary, VET	Invalsi's national surveys of learning	✓	Upper secondary, VET	✓
Japan	X					
Korea	✓	Primary*, Secondary	National Assessment of Educational Achievement (NAEA)	X		✓
Latvia	X			✓	Upper secondary, VET	✓
Lithuania	✓	Primary, Lower secondary, VET	National Student Achievement Test (NSAT)	✓	Secondary, VET	✓
Luxembourg	✓	Secondary, VET	Épreuves Standardisées (EpStan)	X		✓
Mexico						

	National/central student evaluation			National/central student examination		Assessments results stored in (or easily retrieved from) a student information system
	Digitised form	Levels of education where digitised	Name of the digitised assessment(s)	Digitised form	Levels of education where digitised	
Netherlands	✗			✗		
New Zealand	✓	Primary, Lower Secondary	Assessment Tool for Teaching and Learning (e-asTTle)	✓	Upper secondary	✓
Slovenia	✗			✗		✓
Spain	✓	Primary, secondary, VET	Diagnostic assessment, general assessment of the education system	✗		
Sweden	✓	Primary, Secondary	National Student Tests			
Türkiye	✗			✗		
United States	✓	Primary, Secondary	National Assessment of Educational Progress (NAEP)			✓
England (United Kingdom)[2]	✓	Primary	Multiplication Tables Check, Reception Baseline Assessment	✗		✓
Flemish Comm. (Belgium)						
French Comm. (Belgium)				✗		
Total (29)	**18**			**7**		**15**

Notes:
✓ indicates that some parts of the assessments (evaluations or examinations) are digitised.
✓+ indicates that some parts of the digital assessment (not necessarily the main one though) integrate innovative feature, such as adaptive testing. All other digital assessments use uniform testing.
✗ indicates that a national/central assessment exists but that it is not digitised.
A grey cell indicates that no national/central assessment exists.
A star (*) indicates that the assessment is administered at a lower level of government (e.g. province, state, region).
1: In Denmark, only the non-compulsory part of the Folkeskolen's National Skills Test still integrates adaptive features.
2: In England (United Kingdom), the main standardised student evaluations are the End of Key Stages 1 & 2 national curriculum assessments, and they are not digitised.
For more details on OECD countries and jurisdictions' assessments, see OECD Education at a Glance 2023 (https://doi.org/10.1787/dfccf5a6-en).

StatLink https://stat.link/4y7bh2

Out of the 29 countries and jurisdictions for which we have comparative information, two federal countries have digitised the standardised evaluations that they administer or coordinate from the federal level. In Canada, one of the rare missions of the federal government in education is to conduct a Pan-Canadian Assessment Programme (PCAP) that assesses students in grade 8 (secondary education) in reading, mathematics, and science. Across all 10 provinces in partnership with the Council of Ministers of Education, Canada (CMEC), samples of students are drawn to participate in the federal evaluation so that their results are representative of their provinces. In addition to the federal level evaluation, most provinces and territories also conduct their own evaluation on a census basis, in some cases through digital means. In the United States, the National Assessment of Educational Progress (NAEP) is also completely computer-based: while all subjects provide a range of selected-response questions, the digital medium is also used for items that would be difficult to implement non-digitally, such as interactive scenario-based tasks (in the 2018 technology and engineering literacy assessment). Most (if not all) US states and districts carry out digital standardised evaluations. A third federal country, Mexico, used to conduct standardised student evaluations at the federal level, whose results were then stored and transferred for reporting in their *Sistema Integral de Resultados de las Evaluaciones* (SIRE), a 2016 system connected to *SIGE*, the federal student information system (see (Vincent-Lancrin and González-Sancho, 2023[20])). However, the standardised evaluations have been discontinued.

Nordic countries have also long embraced the digitisation of their standardised student evaluation. In Finland, the Finnish Education Evaluation Centre (FINEEC) evaluates randomly selected samples of students in years 3 and 9 (primary and secondary education) to monitor and evaluate the education system. FINEEC started experimenting with digital parts of the national evaluations in 2014, and by 2017 all were fully digitised and taken on *Koda*, FINEEC's own digital evaluation platform. As per its 2020-2023 National Plan for Education Evaluation, Finland envisions to develop new evaluation systems and methods to diversify tasks and allow for automated scoring. In Sweden, the National Agency for Education also undertook the digitalisation of the national student evaluation for students in grades 6 and 9 (primary and secondary education). Since 2018, the answers to essay questions for the Swedish and English language assessments are taken on computers. By 2026, the objective is to have most national assessments entirely digitised and taken from a single digital environment that will allow for direct student identification, innovative assessment design, automated grading, and provide visualisation tools for the results.

A few countries and jurisdictions actively encourage the development of innovative assessment design. In the United States, the federal department of education encourages the implementation of innovative assessment by encouraging state education agencies (SEAs) to apply for the Innovative Assessment Demonstration Authority (IADA) programme and improve state-wide assessments. Since 2018, Louisiana, New Hampshire, North Carolina, and Georgia have joined the IADA programme, which has provided them with the authority to establish and operate an innovative assessment system in their public schools.[1]

Yet, uniform assessments, where all students complete a fixed set of assessment items, are still far more common than adaptive assessments, where the difficulty of the tasks is adapted to students' abilities. Out of 39 countries/jurisdictions, computer-based uniform testing is used in 18, whereas computer-based adaptive testing is used only in Australia (National Assessment Program – Literacy and Numeracy), Denmark (only for non-compulsory assessment in natural sciences as well as in English and in Danish as a second language), France (in the upper secondary entry test) and Scotland (United Kingdom) (for National Standardised Assessments) (OECD, 2023[21]).

While one of the advantages of digitalising assessment is the possibility to implement innovative assessment features, most countries and jurisdictions do not take advantage of these digital affordances yet. On the contrary, some countries explored them before reverting to more traditional (yet digital) forms of assessment. In Denmark, since 2022 and the implementation of the new *Folkeskolen's National Skills Test* in reading and mathematics, the compulsory part of the national student evaluations is no longer *adaptive*. Following complaints from education researchers, politicians on both sides of the political spectrum and parts of the public opinion, they decided to return to *linear* assessments where all students take the same questions in the same order. Students reported that they faced higher stress in answering the first questions of the adaptive assessments, as teachers had warned them that those were the questions that would matter the most for the rest of the assessment and their final outcome. Moreover, teachers faced challenges in explaining why students may experience different assessments, and how parents should interpret their results. The former, adaptive national evaluation will remain available on a voluntary basis in certain disciplines (biology, geography, chemistry, physics, English and Danish as a second language) until the 2025/26 school year.

As of 2024, most countries and jurisdictions that have paper-based standardised student evaluation plan to digitise them to a certain degree. For instance, Japan aims to digitally administer (parts of) its National Assessment of Academic Ability (*Zenkoku Gakuryoku Gakushuu Joukyou Chousa*) by 2025. This low-stake annual national standardised evaluation of Japanese language and mathematics is taken by all students in the final years of primary and lower secondary education. Similarly, Brazil plans to transition to computer-based administration for its Basic Education Assessment System (SAEB) by 2024, starting with students from the last year of primary education to year 3 of upper secondary education (OECD, 2021[22]).

Finally, countries and jurisdictions with no national or central standardised student evaluation planning to develop one typically consider digital administration from the beginning. For instance, by 2024 the Flemish Community of Belgium aims to develop and implement a digital standardised evaluation to support the monitoring of learning outcomes, generate data for research, and help improve the quality and accountability of the education system. It will initially focus on the Dutch language and mathematics. The computer-based administration of the evaluation will allow one to randomly select three out of the ten competences assigned to a school for testing (for example, “number theory”, “geometry” and “statistics” in the case of mathematics). Each student in that school will be assessed in two randomly assigned competences out of the three (for example, “number theory” and “statistics”). As a result, the digitalisation of evaluation will allow to cover all competences while limiting the testing burden on schools and students.[2]

Turning assessment results into formative information

Digitising student evaluation simplifies the transfer, storage of and access to student results at the system level. Linking those results to longitudinal and unique student identifiers provides policymakers, administrators, school leaders and teachers with granular information on students’ results throughout their learning pathways. This is only possible for assessments based on comprehensive cohorts of students. When based on a probability sampling, the assessments still provide a national or jurisdictional benchmark to schools and teachers (assuming they can test their students with comparable tests).

Student information systems (SIS) sometimes integrate, or allow easy linkage to, student standardised assessment results (see (Vincent-Lancrin and González-Sancho, 2023[20])).

Out of 29 education systems for which we have comparative information, 15 can link student unique identifiers to the results of their jurisdictional standardised assessment (see Table 4.1).

Some student information systems are inherently built on the management of standardised evaluation results. In England (United Kingdom), student results to national standardised evaluations are transferred to *Analyse School Performance*, a student information system co-developed (though no longer linked) with the Office for Standards in Education (Ofsted).[3] It helps education stakeholders review and compare national and local authority performances of students, and thereby plan school improvement. *Analyse School Performance* is primarily intended to help schools identify strengths and areas of performance (based on their students’ results). Other data available in *Analyse School Performance* come from a range of sources, including census, exam and performance data collected by the English department for education, or from other sources of data that are sent to the department for education. *Analyse School Performance* uses tables, graphs, and charts to show the attainment and progress of schools, broken down by different contextual factors and student characteristics (ethnic group, poverty status, etc.). Schools can in turn select relevant data from the platform to personalise their own report. The type of information end-users can access on this system varies depending on their status (for instance, administrators and trustees will only be entitled to view non-student-specific information).

In the United States, the results to standardised student evaluation are typically included as a data element in states’ (or jurisdictions’) longitudinal data systems. By contrast, European countries often keep information about students’ results separate from their student information systems, making them only possible to use for research. This may relate to privacy or institutional reasons: in Italy, a specific public agency (Invalsi) is responsible for the national assessment, and it is separate from the ministry of education that administers the national information system; in Luxembourg, the University of Luxembourg (LUCET) is responsible for the administration of the national standardised assessment, and it is separate from the ministry of education (or higher education). In countries and jurisdictions where the information is not directly accessible within the student information system (e.g. Hungary, Italy, Luxembourg or New Zealand), standardised learning outcomes are typically connected to students' unique identifier so that this information can be retrieved through data linkages. Results can then be made available to teachers, schools, and parents as well as to researchers – while being adequately aggregated to preserve anonymity.

Hungary is a good example of a country where student evaluation is an integral part of the student information system used at the national level – although results are no longer directly available in the system. Hungary started collecting information from the National Assessment of Basic Competencies in 2001, but it was only after introducing individual student identifiers in 2007 that the system allowed longitudinal tracking across grades. Since 2010, Hungary has aimed to turn these data into actionable information to school practitioners. Individual reports are available for each student (and the school aggregated reports are open to the public). School principals can connect to the database through the FIT analysis software (*FIT elemző szoftver*) to make customised comparative reports about their school and students and make comparisons with similar schools. Moreover, the Education Authority, an agency of the Ministry of Interior, provides an expert consultant service through its regional pedagogical centres to help schools and teachers understand and utilise the results. In 2022, literacy, mathematics, natural sciences, and languages were assessed and expanding the scope of the information is in progress (history and digital culture). The covered grades were also broadened to students from 4th to 11th grade. This expansion generates results under a new data structure, which will require updating the *FIT analysis software*. The reporting of results is also currently under revision.

Finally, in some countries and jurisdictions standardised assessment results are accessible through the student information systems used by schools – referred to as learning management systems in this report. In Denmark, upper secondary education students take digital assessments on *Netprøver*, a digital platform that automatically checks students' submissions for plagiarism, assigns them grading by appointed examiners, and transfers students' grades to their schools' learning management system. In New Zealand, tabular reports of students' scores to the *Assessment Tool for Teaching and Learning (e-asTTle)* assessment can be easily integrated with schools' learning management systems, thus combining information from tailored assessment with school-level administrative and operations data. A feature of *e-asTTle,* having been initially designed as a formative assessment, is the ability to transform assessment results into prompt and interpretative feedback for teachers and school leaders through a range of graphical reports. These show student progress and areas of weakness and strength, as well as comparing performance at the individual, class or school levels to curriculum requirements, national averages, or normed gender, ethnicity, language, or socio-economic groups. An example is the *Individual Learning Pathway* report, which gives information on a student's strengths and gaps. Another application links assessment results to the *What Next* website, an indexed library of resources to help teachers and learners identify appropriately targeted learning materials. Providing this individualised feedback in real time would be impossible without a digital tool.

Digitalisation of student examinations

In the context of this report, student examinations refer to summative assessments that students typically take at critical points in their learning course, such as at the end of a study year or a study cycle. Those exams carry high stakes for students as they can impact their academic trajectory, access to higher education, career opportunities, or eligibility for scholarships or certifications. Moreover, they are usually taken at the same time by all students. For these reasons, student examinations tend to be administered in a more controlled setting than system evaluations. They require stricter security measures to prevent cheating and maintain equality of exam-taking conditions across examinees. They may also cover a broader range of content and skills as they aim to assess students' comprehensive knowledge and skills in various subject areas. Compared to national evaluations, digitising exams appears as more politically and technically complex.

The digitalisation of high-stakes student examinations also offers potential benefits. Digitising exams enables innovative assessment design, which may ultimately enable the assessment of new types of skills, including digital literacy. As for digital national evaluations, digitised exams may lead to faster results and could perhaps even be an end-of-cycle national evaluations if governments can ensure the fairness, validity, and reliability of the assessment process.

Country coverage

Out of 29 education systems for which we have comparative information, 7 (24%) countries (Denmark, Estonia, Finland, Italy, Latvia, Lithuania, and New Zealand) have partly digitised some of their high-stakes student examinations. In five of them, high school graduation exams are concerned (see Table 4.1, right-hand columns). In other countries and jurisdictions, only subjects that would typically be taken on a computer, such as coding, may be digitised.

In Denmark, students take their end-of-cycle exams on the *Testogprøver* in primary and lower secondary education and *Netprøver* in upper secondary education. In Finland, the high school graduation exam is entirely digitalised (Box 4.2). In Estonia, secondary education students take their exams in presence on an online platform, the *Eksamite Infosüsteem* (EIS). The system also allows schools to register students for exams, to create exam schedules, and to manage other aspects of the examination process: it provides tools for generating exam papers (for paper and pencil exams), for conducting exams digitally, and for processing exam results. In Italy, some parts of the high-stakes end-of-year examinations for upper secondary and VET education are conducted online. To facilitate the management of the examinations process, the ministry has developed the *Commissione Web application* for secondary education and the *Gestione Esami ITS* application for state examinations in VET.

Box 4.2. The Finnish matriculation exams

The fruit of a public-private collaboration

In 2012, Finland decided to digitise the matriculation exams taken by students at the end of secondary education to enter higher education. The ministry publicly procured the services of a private firm specialised in digital products to build a platform operating on the free and open-access Linux operating system. After four years of research and development, in 2016 the first digital exams were held in subjects with a smaller number of candidates: geography, philosophy, and German language. By 2019, all matriculation exams were digitised.

Candidates can take the matriculation exams on their own laptop or borrow one from their schools; whichever they opt for, all students have to access the Linux operating system from a thumb drive distributed by the matriculation board at the start of the exams. In this restrained, self-contained environment, candidates cannot access their local files or the Internet but only the pre-installed software and materials. There is no cloud-based architecture to minimise the risk of technical difficulties: both the assessments and students' answers are saved on offline local severs.

Support from the ministry: a digital tool, capacity building, and a training programme

To support schools in this transition, the Matriculation Examination Board has developed *Abitti*, a digital system for exam administration. *Abitti* provides instructions and guidance on the administration of the digital exams and allows teachers and students to get accustomed to the digital environment before they take the exams. The exam digitalisation was accompanied by an extensive training programme, provided by the ministry in a waterfall approach: across the country, 50 teachers were trained on the platform during a series of workshops so that in turn they could champion this transition and disseminate their knowledge among their peers.

Note: Digital Matriculation Exams: https://www.ylioppilastutkinto.fi/en/matriculation-examination/digital-matriculation-examination

Other countries and jurisdictions plan to digitise their student examinations in the near future. As of 2024, Austria was piloting a digital matriculation exam (*Digitale Reifeprüfung*) in federal schools at the upper secondary level (including VET). The digitalisation of the matriculation exam will accompany the imminent launch of a digital credential system. In England (United Kingdom), all main exam boards were piloting digital exams for the GCSE and A-levels.

Compared to their central or national evaluations, few countries and jurisdictions had digitised their student examinations as of 2024. This is partly because not all countries organise national/jurisdictional graduation or end-of-cycle exams. But other explanations can also be put forward.

First, it may be less advantageous to digitise exams than national evaluations. End-of-course exams may cover a broader range of subjects as they assess students' knowledge and mastery of specific learning cycles, which reduces the gains from replication over time and automation.

Second, exams carry high stakes for students. Historically, attempting to innovate such exams in one way or another has led to stronger resistance from education stakeholders and the general public. Cultural norms and societal attitudes may favour traditional pen-and-paper exams as a wide range of stakeholders, including students, parents, educators, and employers, may have reservations about the validity and reliability of digital exams. Security, equity, and technical issues are also often brought forward. Digitising exams requires that countries and jurisdictions develop a solid digital infrastructure that allows for strict security measures (against cheating, hacking, etc.), equitable access for all students everywhere, equivalent student proficiency in using computers, and proven robustness against technical glitches or device malfunction . They also require sufficient physical spaces with the electrical and network facilities suitable for numbers of students to take the assessments on devices concurrently. In addition, it often requires changing the format of the exams and to negotiate this change socially.

However, while the process tends to be slower than for mere system evaluations, it is likely that an increasing number of countries and jurisdictions will digitise their national exams given the emphasis on student "digital competencies" of most curricula. Transitioning from paper-based to digital exams demands long-term planning but also investments in a sufficient, secure hardware infrastructure, inclusive of connectivity and digital equipment in schools (or exam centres).

Digital tools to support assessment

Countries and jurisdictions have developed a host of digital systems to support the administration of their assessment, whether (low-stakes) system evaluations or (high-stakes) student examinations. Those systems typically provide a digital environment for the administration of digital assessments; but they can also assist with the administration of paper-based assessments (e.g., student registration, distribution, completion), or facilitate the grading and transfer of grades to other digital systems or registers. Finally, some support systems were developed to enable the remote proctoring of students during assessments.

Country coverage

Out of 29 countries and jurisdictions for which we have comparative information, 16 (more than half) have developed digital tools to support the administration of assessments, whether the assessments are digital or not, and whether they consist in evaluations, formative assessments, or high-stakes exams (see Table 4.2).

Table 4.2. Digital tools to support assessment: availability and characteristics (2024)

	Use or provide a digital system to support assessment	Name	Levels of education	Types of assessment supported
Austria				
Brazil	✓	SAEB support systems, Painel Educational	All	Standardised evaluation
Canada				
Chile	✓		All	Both exams and standardised evaluations
Czechia	✓	InspIS SET platform	Primary and secondary education	Standardised evaluation and design of new assessment
Denmark	✓	Testogprøver, Netprøver, XPRS	All	Both exams and standardised evaluation
Estonia	✓	Eksamite Infosüsteem (EIS)	Secondary education (including VET)	Both exams and standardised evaluation
Finland	✓	Koda, Abitti	Upper secondary education	Both exams and standardised

	Use or provide a digital system to support assessment	Name	Levels of education	Types of assessment supported
				evaluation
France	✓	Cyclades, Pronotes & ASP	Upper secondary education (including VET)	Both exams and standardised evaluation
Hungary	✓	Data collection and management system for national measurements (“Országos mérések adatbegyűjtő és - kezelő rendszere “), FIT analysis software (“FIT elemző szoftver”), FIT-jelentések	Primary and secondary education (including VET)	Standardised evaluation
Iceland				
Ireland	✓	Digital grading for the national assessment + Machine coding services for the (optional) paper-based Drumcondra assessment	Upper secondary education (including VET)	Standardised evaluation
Italy	✓	Commissione Web, Gestione Esami ITS	All	Both exams and standardised evaluation
Japan	✓	MEXCBT	Primary and secondary education	Both exams and standardised evaluation
Korea				
Latvia	✓	ProctorEdu	Secondary education (including VET)	Olympiads (competitive but low stakes)
Lithuania	✓	TAO’s NECIS	All	Both exams and standardised evaluation
Luxembourg	✓	PFS and BAC, and Oasys	Primary and upper secondary education	Both exams and standardised evaluation
Mexico				
Netherlands				
New Zealand				
Slovenia				
Spain	✓	Platform for EGS and ED	All	Standardised evaluations
Sweden	✓	Skolverkets provtjänst	Primary and upper secondary education	Standardised evaluations
Türkiye				
United States				
England (United Kingdom)				
Flemish Comm. (Belgium)				
French Comm. (Belgium)				
Total (29)		**16**		

Note: N=29

StatLink https://stat.link/fux7q1

To provide an environment for digital assessment

By definition, digital assessments are taken on a digital testing platform. Countries and jurisdictions that have entirely digitised their national evaluations (or are in the process of doing so) provide a digital environment to support their administration and their completion. In Luxembourg, for the national student evaluation (Épstan), all students from specific grades take their computer-based test on the *Oasys* platform, which was developed by the University of Luxembourg (LUCET) in close collaboration with the ministry. In Sweden, which aims to digitise most of its national evaluations by 2026, the national agency for education has developed *Skolverkets provtjänst* ("Test service"), a digital system for assessment administration that provides a single environment for student's identification and assessments' design, delivery, grading (automatic and manual) and results.

In Hungary, multiple digital tools support the administration, management and analysis of the standardised evaluation. Schools have to use a data collection and management system for national measurements (*Országos mérések adatbegyűjtő és -kezelő rendszere*) to manage and organise the assessment (e.g. ensuring students take part in the right assessment on the right day) and to anonymise student results via identifiers. With another software (*Tehetsegkapu*), students can assess their preliminary results, before final results are available on a dedicated website (*FIT-jelentések*) in the form of automated reports. Schools, at their end, have access to preliminary results on their own platform (*intézményi gyorsvisszajelző*). Eventually, stakeholders can use the FIT analysis software (*FIT elemző szoftver*) to analyse the results of the assessment.

Such support tools also exist in countries and jurisdictions that have digitised (parts of) their central examinations. This is for instance the case of Lithuania's *NECIS* system, an open-source online system provided by TAO.[4] *NECIS* is used both for administering several parts of the national student assessments, which are carried out online in mathematics and in Lithuanian, as well as for administering some parts of the final exams in upper secondary education (including VET). After a pilot phase, the objective is to fully digitise both types of assessments by 2026, so that exams and evaluations are entirely administered, taken, and graded online through digital systems such as NECIS. Finland's *Abitti* system (see Box 4.2) is also used to support and monitor the administration of matriculation exams. In Italy, the ministry has developed the *Commissione Web application* for secondary education examinations and the *Gestione Esami ITS* application for state examinations in VET. In Denmark, the ministry manages the administration of the student evaluations and exams, which students take on *Testogprøver* and *Netprøver*, with the *XPRS* tool.

To support the design of teacher-given assessments

Alongside the digitalisation of assessments conducted at the system level, countries and jurisdictions have developed digital assessment tools for the benefits of teachers. This category ranges from public banks of assessment items to tools that are made modulable so that teachers can design and carry out their own formative or summative assessments with their students.

In the Czechia, the *InspIS SET platform* was primarily developed to administer the country's digital standardised evaluation. But schools and teachers can also use the *InspIS SET platform* to carry out their own assessments online, using their own items, or picking from a public bank of test items – which will soon be supplemented by items released from international assessments. In Brazil, digital tools support the administration of the *Basic Education Assessment System* (SAEB), the paper-based national standardised assessment in literacy and mathematics. While insufficient digital infrastructure and logistic constraints has posed challenges to the digitalisation of this evaluation, the federal government provides states and schools with digital tools that facilitate its administration on paper, in particular as regards logistics and financing. Similarly to the Czech platform, teachers can leverage some of those tools for their own assessments, using banks of items (e.g. BNI) a grading essays. Some of those tools are maintained by the federal or local governments whereas others are procured from private contractors for use during the assessment.[5]

Some countries and jurisdictions centrally provide digital tools for teachers' formative assessment. In Chile, the *DIA* is available online, on a voluntary basis, for schools willing to assess their students in core subjects as well as their socio-emotional skills. *DIA* is an example of a digital formative assessment, designed to be delivered by teachers at three distinct moments of the school year: a diagnostic assessment to begin with, a follow-up halfway, and a closing assessment at the end. Albeit available for all grades, *DIA*'s uptake is larger in primary schools. In New Zealand, the New Zealand Qualification Authority (NZQA) has provided an *Assessment Tool for Teaching and Learning* (e-asTTle) since 2002. *E-asTTle* is an educational platform that enables educators to design and generate standardised and curriculum-aligned tests in reading, writing and mathematics in either English or Māori languages, in primary and secondary levels of education. A large bank of calibrated items allows teachers to customise assessments to the specific needs of their classrooms. Contrary to other computer-assisted assessment systems, *e-asTTle* was also designed with a strong emphasis on formative assessment. Those two examples of digital assessments differ from the self-assessment resources discussed in Chapter 5 (Yu, Vidal and Vincent-Lancrin, 2023[23]) in the sense that they are meant to be administered by teachers but benefit from a large-scale administration that can allow for comparisons across schools and school boards. Self-assessment resources can be accessed and used by individual people.

To support the administration of paper-based assessments

Countries and jurisdictions have also developed digital tools to support the administration of non-digital assessments. In Chile, the government publicly provides digital tools to support the administration of SIMCE (*Sistema de Medición de la Calidad de la Educación*), the paper-and-pencil national evaluations. They include online item grading platforms and digital tools for data reading and processing. In Luxembourg, the ministry requires schools to manage the administration of the two end-of-cycle exams with two separate digital tools: *PFS* supports the management of the national exam at the end of primary education, and *BAC*, the national end-of-secondary-school exam. Those two tools embark features that facilitate student registrations, grading, and tracking of their exam sessions.

Finally, in education systems where standardised evaluations are run on probabilistic samples of students (as is often the case), educational authorities may provide regional administrators and schools staff with digital tools to assist them with the administration of the assessment. In France for instance, several standardised student evaluations coexist: *Cedre* (mathematics and literacy), *LSE* (digital reading literacy), *Socle CE1* (mathematics and literacy in grade 2), *Socle Sixième* (mathematics and literacy in grade 6), as well as TIMMS and PISA. All tests are administered on randomised samples of students. To support sampled schools in the administration of the right assessments to the right students, the ministry has developed a digital tool, called *Application de Suivi des Passations* (ASP).

To support the grading of exams and the transfer of grades

Digital tools are also used to support the grading of paper-based exams. Those tools may enable collaborative grading and automated grade sharing with the educational authorities in charge of the examination.

In France, the ministry of education has developed a platform called *Cyclades* to support the grading of its paper-based high school graduation examination. Since June 2021, schools scan and digitise the end-of-high-school and other high-stake exams' response sheets, filled in by students with paper and pencils; teacher-graders grade the copies online, annotate the document and leave comments that students can access almost instantly after the validation process. This in principle avoids the possible loss of response sheets, but could also, over time, give rise to the machine analysis of the response sheets.

In Ireland, the high school graduation exams are also administered as paper-based assessments. The State Examinations Commission (in charge of secondary education high-stakes assessments) uses a digital platform to support their grading. In a low-stakes context, Ireland's Educational Research Centre (ERC) also offers machine coding services for schools that administer the (optional) *Drumcondra* standardised assessments on paper.

To enable proctoring

A less common type of digital systems provided by educational authorities to support the administration of assessments are proctoring systems. Proctoring systems are digital tools used to monitor students during online (or offline, digital) assessments, preventing them from cheating and from unauthorised activities during a remote exam (and sometimes a computerised exam). When the exam or test is taken remotely, they may ensure the integrity of the assessment by employing methods such as video monitoring as well as screen, keystrokes, or mouse tracking. In many countries and jurisdictions, the use of proctoring systems in education is perceived as intrusive and raising privacy concerns (Nigam et al., 2021[24]).

Latvia uses an AI-based proctoring system (*ProctorEdu*) to monitor secondary education students participating in school subject Olympiads, a range of competitive but low-stakes assessments for students throughout the country. The monitoring tool features desktop, audio and video recording, biometric verification of users' identity as well as real-time behavioural monitoring of the test sessions (among other features). Candidates log in and sit the assessment at any time, in any place, and on any device, in asynchronous and synchronous ways. As of 2024, the system was no allowed for high-stakes state examinations.

The Finnish and Danish examples presented above illustrate a more limited form of digital proctoring for in-presence exams: digital proctoring system merely limit the computer environment while humans continue to proctor the exam as would be the case for a paper-and-pencil test. One can imagine that this form of proctoring may become more common to limit the uses of generative AI until new forms of assessment are developed and tested.

Summary: key insights, reflection, and possible trends

More and more countries and jurisdictions digitise the student assessments that they administer at the central or jurisdictional levels. Digital assessments can be adaptive and more personalised; they may assess skills in ways that paper-and-pencil do not allow; they may power learning analytics; they can provide flexibility to allow for remote exams in certain situations; and they can improve the cost-efficiency of assessments through automation (e.g., grading), replication over time, and lowered long-term administration costs. However, more innovative forms of assessment can be costly to develop and not be appropriate for high stakes exams. Concerns relate to the validity, reliability, and security of the assessments. They can also raise an equity issue, given digital divides in terms of hardware, software and human competences. And the digitisation process may infer transitions costs and a path dependency that can be more difficult to disrupt than in the case of paper-and-pencil assessments or exams.

Digitising the simpler things first

Low-stakes evaluations are twice as often digitised as exams. Out of 29 education systems for which we have comparative information, 18 have digitised (part of) their standardised student evaluation. Among them, 7 have also digitised (part of) their student examination. No country has embarked in the digitalisation of high-stakes exams without experimenting with the digitalisation of low-stakes evaluations in parallel.

This chapter suggests four main reasons to explain why exams are less often digitised than evaluations. First, digitising low-stakes standardised evaluations is less complex than digitising exams. Second, because student exams carry higher stakes for students and families, attempting to innovate them leads to stronger political resistance from education stakeholders. Third, because exams are high stakes and must be fair, it is difficult to implement them in an educational environment that is not digitalised, which may become the case as countries and jurisdictions develop students' digital skills. Transitioning to digital exams for entire cohorts of students often require stronger investments in digital infrastructure, including investments in the training and digital literacy of teachers and school staff.

Our comparative data collection further suggests that countries and jurisdictions tend to use the digitalisation of their student evaluation as a first step towards the possible digitalisation of their exams, if any. The transition from paper-based to digital evaluations has required countries to strengthen their digital infrastructure in schools, in assessment centres, or directly at students' place of residence.

Whether they have digitalised their national or not, countries have developed digital tools that support the administration of assessments. 16 out of 29 education systems use such support tools. Most tools are used to provide a digital environment for the administration of digital evaluations or, to a lesser extent, digital exams; but some support the administration of paper-based assessments (e.g., student registration, distribution of exam tasks, completion status), or facilitate the grading and transfer of grades to other digital systems or registers. Only one country (Latvia) uses an AI-based digital proctoring system in a low-stake context.

A digitalisation without transformation?

As of 2024, countries and jurisdictions that had digitised (part of) their student assessment had usually not used many innovative affordances allowed by digital assessments. In terms of content and design, most digitised assessments replicate the paper-based assessments they replaced. Almost no assessment uses adaptive assessment techniques, not to mention games, simulations or scenario-based formats. Denmark tried to embed adaptive features to its low-stake standardised evaluation before policy makers decided to revert to a traditional design given the resistance of the public opinion.

Even the most innovative digital features, such as the use of digital assessment environments or proctoring systems, are usually deployed to replicate the conditions of traditional, paper-based assessments taken in class. As of 2024, the advantages of digitising assessments have mainly lied in the simplification of the administration, data management and sometimes grading processes. Most common data linkages are done with jurisdictions' student information systems (or central student registers).

Looking forward: where to go next?

Addressing technical challenges. Digital assessments have technical prerequisites, which include access to enough compatible devices; sufficiently reliable Internet and/or local network capabilities; sufficient staff with the expertise to support the introduction and ongoing use of computer-based assessment; physical spaces with the electrical and network facilities suitable for numbers of students to take the assessments on devices concurrently; and strong IT infrastructure to manage security risks. An offline modality of taking the assessment may provide a means for minimising some of these risks, but this requires some additional time and guidance to schools for installing the software beforehand and limits the use of digital tools and the adaptability of the assessment. Countries willing to meet these requirements will have to plan for an initial financial investment and ongoing maintenance costs.

More innovative assessment features. The transition to digital assessments opens up opportunities for incorporating more innovative features into the assessment process. However, our data collection shows that we are not there yet. Perhaps the new assessments that will be designed, from their infancy, to be taken digitally, may embark more innovative assessment features than those that were mainly designed to replace their paper-based counterparts. The next generation of digital assessments could foster the deployment of personalised learning experiences, adaptive features that adjust based on student performance, automated grading that allows for quicker feedback and immediate access to results, among other digital affordances. Countries will seek to transform their assessment practices to reap the benefits of the digital transformation in education.

Broader content coverage. As of 2024, most of the digital assessments developed and administered by countries and jurisdictions are digitised versions of their standardised evaluation, hence they mostly assess students' literacy and numeracy. Yet, digital assessments provide the means to evaluate a broader range of subjects and competences, including other traditional curricular subjects than language and mathematics, but also a wider set of knowledge, skills, attitudes, and values. Countries that seek to integrate digital competences into teachers pre-service and in-service training, or into curriculum requirements, should also look to measure those skills so as to monitor all education actors' digital literacy. Digitising assessment serves both as a means and as an end to that.

Better integration within countries' assessment ecosystem. Countries and jurisdictions may explore how to better integrate their digital assessments into their broader assessment ecosystem, where different education stakeholders have access to different assessment resources, such as past exams or sample of items that teachers can use to create their own assessment; or that students can use for self-assessment. They can also be readily integrated within countries' digital credential systems.

Better linkages with other education and student information systems. Sitting a digital assessment typically requires students to self-identify online or on a digital platform, using unique identifiers – except in the context of sample-based assessments where student results are aggregated. This allows to store and transfer student results and, if those identifiers are longitudinal, to monitor students' progress and trajectory over time. This linkage is typically done through student information systems; and allow schools and teachers to compare their students' results with other (similar) schools and teachers. Additionally, student results to digital assessments can be immediately and automatically mobilised as key signals by early warning systems, that can help make visible students who are at risk of dropping out, for instance (see (Vidal, 2023[25])).

Easier and deeper access to data for research. Digital assessment offers advantages over paper-based assessment in terms of data accessibility and analysis. With digital assessments, or with digital tools that support the administration of paper-based assessments, student data may be scored automatically and stored electronically, allowing for easy and quick access. Building on appropriate data governance to mitigate the risks posed to data protection and privacy (see (Vincent-Lancrin and González-Sancho, 2023[26])), these digital capabilities streamline the research process, making it more efficient and reliable compared to handling similar amounts of paper-based data. Furthermore, if those data are tagged with unique, sometime longitudinal, student identifiers, then they may provide even richer insights for research when integrated with other student and school information stored in other databases.

References

Buckley, J.; L. Colosimo; R. Kantar; M. McCall and E. Snow (2021), "Game-based assessment for education", in *OECD Digital Education Outlook 2021: Pushing the Frontiers with Artificial Intelligence, Blockchain and Robots*, OECD Publishing, Paris, https://doi.org/10.1787/9289cbfd-en. [3]

Foster, N. (2023), "Teacher digital competences: formal approaches to their development", in *OECD Digital Education Outlook 2023. Towards an Effective Digital Education Ecosystem*, OECD Publishing, https://doi.org/10.1787/c74f03de-en. [5]

Fragoso, T. (2023), “Hardware: the provision of connectivity and digital devices”, in *OECD Digital Education Outlook 2023. Towards an Effective Digital Education Ecosystem*, OECD Publishing, https://doi.org/10.1787/c74f03de-en. [4]

Kimura, T. (2017), “The impacts of computer adaptive testing from a variety of perspectives”, *Journal of Educational Evaluation for Health Professions*, Vol. 14, p. 12, https://doi.org/10.3352/jeehp.2017.14.12. [14]

Kolen, M. and R. Brennan (2014), *Test Equating, Scaling, and Linking*, Springer New York, New York, NY, https://doi.org/10.1007/978-1-4939-0317-7. [12]

Leaton Gray, S. and N. Kucirkova (2021), “AI and the human in education: Editorial”, *London Review of Education*, Vol. 19/1, https://doi.org/10.14324/lre.19.1.10. [6]

McClelland, T. and J. Cuevas (2020), *A comparison of computer based testing and paper and pencil testing in mathematics assessment*. [11]

Nigam, A.; R. Pasricha; T. Singh and P. Churi (2021), “A Systematic Review on AI-based Proctoring Systems: Past, Present and Future”, *Education and Information Technologies*, Vol. 26/5, pp. 6421-6445, https://doi.org/10.1007/s10639-021-10597-x. [24]

OECD (2023), *Country Digital Education Ecosystems and Governance. A companion to Digital Education Outlook 2023*, OECD Publishing, https://doi.org/10.1787/906134d4-en. [18]

OECD (2023), *Education at a Glance 2023: OECD Indicators*, OECD Publishing, Paris, https://doi.org/10.1787/e13bef63-en. [19]

OECD (2023), “Strengthening the design and implementation of the standardised student assessment reform of the Flemish Community of Belgium”, *OECD Education Policy Perspectives*, No. 72, OECD Publishing, Paris, https://doi.org/10.1787/85250f4c-en. [17]

OECD (2023), “What assessments and examinations of students are in place?”, in *Education at a Glance 2023: OECD Indicators*, OECD Publishing, Paris, https://doi.org/10.1787/dfccf5a6-en. [21]

OECD (2021), “National assessment reform: Core considerations for Brazil”, *OECD Education Policy Perspectives*, No. 34, OECD Publishing, Paris, https://doi.org/10.1787/333a6e20-en. [22]

OECD (2021), *OECD Digital Education Outlook 2021: Pushing the Frontiers with Artificial Intelligence, Blockchain and Robots*, OECD Publishing, Paris, https://doi.org/10.1787/589b283f-en. [1]

OECD (2020), “Remote online exams in higher education during the COVID-19 crisis”, *OECD Education Policy Perspectives*, No. 6, OECD Publishing, Paris, https://doi.org/10.1787/f53e2177-en. [2]

OECD (2013), *Synergies for Better Learning: An International Perspective on Evaluation and Assessment*, OECD Reviews of Evaluation and Assessment in Education, OECD Publishing, Paris, https://doi.org/10.1787/9789264190658-en. [15]

Ofqual (2020), *Online and On-screen Assessment in High Stakes, Sessional Qualifications: A Review of the Barriers to Greater Adoption and How These Might Be Overcome*, https://assets.publishing.service.gov.uk/government/uploads/system/upl. [10]

Sandene, B.; N. Horkay; R.E. Bennett; J. Braswell; B. Kaplan and A. Oranje (2005), *Online Assessment in Mathematics and Writing: Reports from the NAEP Technology-Based Assessment Project*, https://files.eric.ed.gov/fulltext/ED485780.pdf. [13]

Somers, G. (2021), *Feasibility Study into the Introduction of Central Assessments in Flanders: Legal-technical Aspects (Lot 3)*. [16]

Timmis, S.; P. Broadfoot; R. Sutherland and A. Oldfield (2015), "Rethinking assessment in a digital age: opportunities, challenges and risks", *British Educational Research Journal*, Vol. 42/3, pp. 454-476, https://doi.org/10.1002/berj.3215. [8]

Veldkamp, B. and C. Sluijter (eds.) (2019), *Theoretical and Practical Advances in Computer-based Educational Measurement*, Springer International Publishing, Cham, https://doi.org/10.1007/978-3-030-18480-3. [7]

Vidal, Q. (2023), "Digital assessment", in *OECD Digital Education Outlook. Towards an Effective Digital Education Ecosystem*, OECD Publishing, https://doi.org/10.1787/c74f03de-en. [25]

Vincent-Lancrin, S. and C. González-Sancho (2023), "Data and technology governance: fostering trust in the use of data", in *OECD Digital Education Outlook 2023. Towards an Effective Digital Education Ecosystem*, OECD Publishing, https://doi.org/10.1787/c74f03de-en. [26]

Vincent-Lancrin, S. and C. González-Sancho (2023), "Education and student information systems", in *OECD Digital Education Outlook 2023. Towards an Effective Digital Education Ecosystem*, OECD Publishing, https://doi.org/10.1787/c74f03de-en. [20]

Wyatt-Smith, C., B. Lingard and E. Heck (2021), *Digital Disruption In Teaching And Testing*, Routledge, New York, https://doi.org/10.4324/9781003045793. [9]

Yu, J., Q. Vidal and S. Vincent-Lancrin (2023), "Digital teaching and learning resources", in *OECD Digital Education Outlook 2023. Towards an Effective Digital Education Ecosystem*, OECD Publishing, https://doi.org/10.1787/c74f03de-en. [23]

Notes

[1] United States: Innovative Assessment Demonstration Authority: https://www2.ed.gov/admins/lead/account/iada/index.html

[2] The curriculum competences assessed will vary among students in the Flemish system and even within schools. In this example, two-thirds of the students in that particular school will get assessed on the competence "number theory", two-thirds of the students will get assessed on the competence "geometry" and two-thirds of the students will get assessed on the competence in "statistics". Other schools could be assigned three different mathematics competences out of the ten available (OECD, 2023[17]).

[3] In the England (United Kingdom), the Standards and Testing Agency administers *Multiplication Tables Check*, a statutory digital assessment for all Year 4 students (8-9 years old, primary education). As of 2023, another statutory assessment for measuring English and maths skills of new primary school students,

Reception Baseline Assessment, is administered partially digitally, but the department is considering digitalising it further. In addition, a new *Digital Test for Literacy and Numeracy* is in the pipeline, which will involve a series of short digital activities and will be taken by Year 9 students (13-14 years old, secondary education).

[4] TAO: https://www.taotesting.com/

[5] Brazil's National Bank of Assessment Items (BNI): https://www.gov.br/inep/pt-br/areas-de-atuacao/avaliacao-e-exames-educacionais/bni

5 Digital teaching and learning resources

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This chapter provides an overview of countries and jurisdictions' public provision of digital teaching and learning resources. It examines the involvement of central and jurisdictional governments in this provision and the different modes of public delivery, from the open provision of educational content through to the curation of curriculum-aligned resources on dedicated platforms. Taking stock of this panorama, including the relative absence of smart digital learning resources, the chapter highlights the need to go from provision to use and makes suggestions to move towards effective ecosystems of digital teaching and learning resources.

Introduction

Digital teaching and learning resources constitute a broad suite of educational materials that are formatted for digital use. Such resources can be considered static, taking the form of digital textbooks, audio and video contents, courses, or articles; or dynamic, leveraging interactive features and adaptive contents to provide more personalised learning in interactive learning environments (quizzes, games, simulations, etc.). Digital teaching and learning resources serve different purposes and cater to students and teachers as well as to broader audiences.

Digital teaching and learning resources offer a range of opportunities to advance quality and equity in education. Compared to traditional learning resources, digital resources offer cost-efficiency as the digital format allows for extensive and affordable distribution. They are available anytime and anywhere, providing greater flexibility and accessibility for students and teachers. They may also help teachers teach subjects that would be difficult to teach in a classroom and offer breakthrough educational experiences, for instance through augmented reality (AR) and virtual reality (VR).

But their greatest promise probably lies in the potential they hold to allow for more personalised learning. Digital features can make learning more interactive, more engaging, more adaptive, and more inclusive of students with special education needs. Powered by algorithms and AI, intelligent tutoring systems can be deployed to support students more individually. Similarly, classroom analytics software can make use of the wealth of data generated and collected through interaction with digital tools and resources to provide teachers (and students themselves) with more detailed, sometimes real-time feedback on the way they teach and learn.

This chapter aims to provide an overview of countries' digital infrastructure related to teaching and learning resources. Three other chapters cover the digital infrastructure of system and school management tools: student information systems (EMIS), digital assessments, and learning management and other system and school management tools. This chapter provides an overview of the digital resources that countries and jurisdictions provide publicly, notably to teachers and students, based on a questionnaire to which 29 countries and jurisdictions responded. The information collected was verified and enriched through a series of bilateral meetings, country consultation and desk-research, that eventually underpinned the description of countries' ecosystem of digital teaching and learning resources, among other things (see the related publication (OECD, 2023[1]), where more details on each country can be found).

Across countries and jurisdictions, different stakeholders share responsibility for providing digital teaching and learning resources to schools, teachers, and students. While this chapter focuses on the extent to which central and jurisdictional governments are involved in the public provision and procurement of digital teaching and learning resources, it also aims at mapping their provision from sub-governmental layers such as states, regions, and municipalities.

The chapter is organised as follows. First, it provides a state of the art of the digital teaching and learning resources that countries and jurisdictions (sub-national levels of government) provide publicly, in particular to schools, teachers, and students. The chapter distinguishes educational content that is openly and often indistinctly provided to the general public, through TV and radio broadcasts, social media channels, and national MOOC platforms from resources that are curated on dedicated educational platforms for more specific, curriculum-aligned, purposes – though they may include open educational resources (OER) in practice. Then, the chapter explores the typology of those resources, covering static and interactive resources, inclusive of self-assessment resources and digital textbooks. Then, it looks at other elements that compose countries' digital teaching and learning infrastructure, ranging from platforms for teacher development and for online student tutoring, up to more advanced digital tools such as intelligent tutoring systems and classroom analytics. The conclusion finally provides a summary of the information and points for policy makers to consider moving forward.

A state of the art

Our comparative analysis covers 29 countries and jurisdictions. All countries were invited to complete a set of policy questionnaires, and the responses were subsequently verified through bilateral interviews by the OECD Secretariat. This information underwent thorough cross-validation for the preparation of a detailed descriptive analysis of country digital education ecosystems and governance (OECD, 2023[1]).

Although meticulous efforts were made to authenticate data on digital resources' availability, it was not always possible to do so comprehensively. This limitation was due in part to several resources' exclusive availability to those who are formally enrolled in the education sector. Nonetheless, all data were verified by the respective countries and the OECD Secretariat to ensure utmost data accuracy and integrity.

Division of public responsibility

Across countries and jurisdictions, different stakeholders share responsibility for providing digital teaching and learning resources to schools, teachers, and students. This chapter focuses on the public provision of resources from central and jurisdictional governments, mapping the provision of resources from national but also sub-governmental layers such as states, regions, and municipalities. Other actors sell or offer digital learning resources, including NGOs, researchers, teachers, universities, philanthropic bodies. Schools, teachers, and students may directly acquire products from EdTech firms, but this chapter focuses on the extent to which governmental authorities are involved.

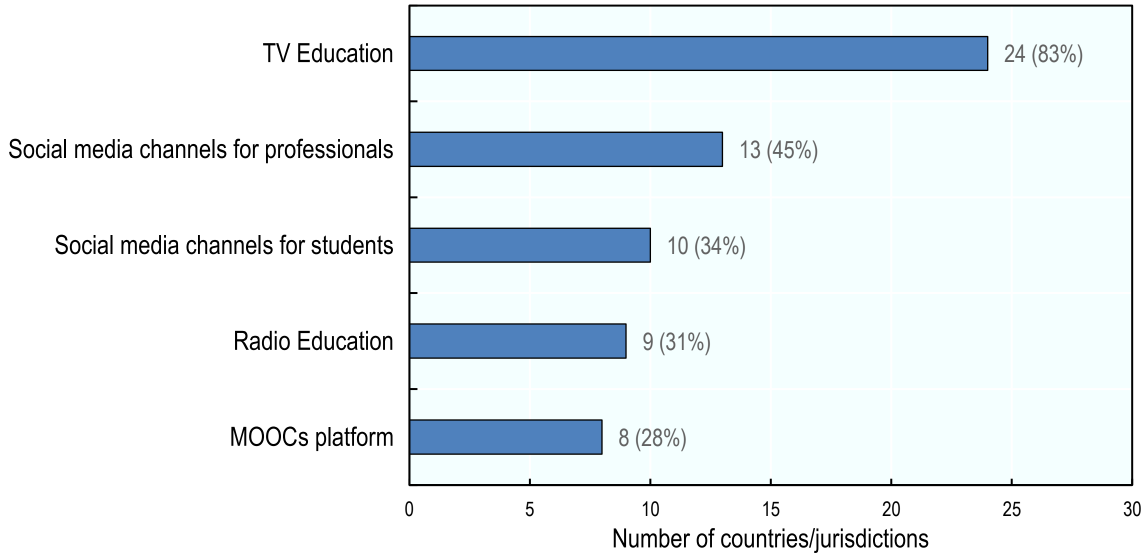
The extent of government involvement in the provision and procurement of digital resources differs across countries, and it is somewhat shaped by the usual devolution of responsibilities within its education ecosystem. In places like Canada and the United States where responsibilities are devolved to regional authorities, the federal participation in the provision of teaching and learning resources is minimal or inexistant. National ministries in Austria, Brazil, and Mexico are more engaged. In non-federal countries, the central government's involvement also fluctuates, from minimal in the Netherlands to preponderant in Hungary and Korea, which see substantial governmental contributions to developing and providing digital resources. In most countries there is a mixed model of provision, with the government providing resources and schools procuring others, such as in New Zealand. In England, an arm's length body develops and provides digital teaching and learning resources under government commission. Where governance is heavily decentralised, municipal authorities, seen in Nordic countries for instance, often augment resource provision through procurement.

Regardless of whether they are developed publicly, procured by governments, or directly acquired by schools, few digital teaching and learning resources are compulsory to use. Consequently, schools and teachers typically maintain autonomy in their choice of providers and may exhibit a preference for certain digital resources over others.

Open provision of educational content

The majority of OECD countries for which we have comparative information have a wide variety of digital teaching and learning resources that they make openly available to anyone in the country (see Figure 5.1 and Table 5.1). Although this mode of public delivery predates the 2020 COVID-19 crisis, in many countries the open provision of learning content available for anyone is a legacy of policies tailored to ensure education continuity during school closures, especially through TV and radio broadcast. This section focuses on digital teaching and learning resources that are provided through broad and open delivery. Learning resources that are curated on online educational platforms, some of which are accessible to anyone who signs up on the platform, are covered in the next section.

Figure 5.1. A snapshot of the public provision of open digital education content (2024)



Note: N=29.

StatLink https://stat.link/3nqprs

Table 5.1. Public provision of open digital education content (2024)

	TV Education	Radio Education	Social media channels for students	Social media channels for professionals	MOOC platform
Austria	✓	✓		✓	✓
Brazil					✓
Canada	✓*				
Chile	✓	✓	✓	✓	✓
Czechia	✓			✓	
Denmark					
Estonia				✓	
Finland	✓				
France	✓				✓
Hungary	✓				
Iceland	✓	✓			
Ireland	✓	✓	✓	✓	
Italy	✓		✓	✓	
Japan	✓	✓	✓	✓	✓
Korea	✓		✓	✓	✓
Latvia	✓		✓	✓	
Lithuania	✓				
Luxembourg					
Mexico	✓	✓	✓	✓	✓
Netherlands	✓				
New Zealand	✓			✓	

	TV Education	Radio Education	Social media channels for students	Social media channels for professionals	MOOC platform
Slovenia	✓				
Spain	✓		✓	✓	✓
Sweden	✓	✓		✓	
Türkiye	✓				
United States	✓*	✓*	✓*		
England (United Kingdom)	✓	✓			
Flemish Comm. (Belgium)					
French Comm. (Belgium)	✓		✓		
Total (29)	**24**	**9**	**10**	**13**	**8**

Note: A star (*) indicates that the provision is publicly conducted from a sub-governmental level, e.g. provinces and territories in Canada and states in the United States. N=29.

StatLink https://stat.link/103d7j

TV and radio content

As of 2024, 24 of the 29 countries and jurisdictions for which we have comparative information (about four fifths) deliver educational content through public TV or radio broadcasters, sometimes live but in most cases as video or audio contents available online for replay. These broadcasts span fundamental subjects, such as language and mathematics, as well as other subjects. They primarily target school-age students but are openly accessible to anyone. Therefore, while the creation of these educational broadcasts is not always centralised or guided by the government, their content is often mapped to the national curriculum. An exception is Slovenia, where the content usually differed from the curriculum, but alignment was sought during the pandemic.

Broadcasts on public TV or radio channels are generally available on websites for replay, as seen with Italy's *RAI Scuola* and Sweden's *URplay*, or on social media channels managed by the ministries, such as ministry's YouTube channel in French Community of Belgium. Since the reopening of schools post-COVID-19, Iceland and Lithuania have discontinued live broadcasts, but retain online access.

Social media channels

Countries and jurisdictions also leverage social media channels to deliver teaching and learning resources, for learner, teachers, or both. Out of the 29 respondents, 10 utilise social media to deliver educational content to students; and 13 to provide teachers and educators with teaching content. YouTube stands out as the favoured platform, often used for disseminating information and educational content to a broad audience of students and teachers – sometimes rechannelling content that was broadcast on TV. While other social media platforms like Facebook and Twitter are employed to promote educational events or initiatives, they see less utilisation for teaching and learning compared to YouTube. Some sub-governmental authorities run their own social media channels too, as in Estonia (the municipality of Tartu) and Japan.

Massive Open Online Courses (MOOC)

Finally, eight countries also maintain a national MOOC platform: Austria, Brazil, Chile, France, Japan, Korea, Mexico, and Spain. These platforms cover a diverse range of topics from language to programming and offer courses at all education levels – although more often suited for older students and adults.

In France, the France Digital University ("France Université Numérique" [FUN]) platform is a MOOC platform that openly provides courses designed by higher education institutions and associated stakeholders. Courses on FUN are explicitly open to anyone interested in learning a new topic. Some of the courses grant a digital certification upon completion. In Mexico, the federal government maintains the MexicoX platform with the same objectives. Spain's platform hosts courses that enhance digital skills for educational purposes, effectively functioning as a platform for teaching development. It is important to note that MOOC platforms exist in more countries than those five, but they are most often commercial – rather than publicly provided – platforms. In Japan, the Ministry of Education, Culture, Sports, Science and Technology has developed the Japan Virtual Campus (JV-Campus) platform as part of its Top Global University Project (TGUP). The platform contains MOOC created by Japanese universities. It is designed to promote the internationalisation of (higher) education, and as such mainly offers higher education level courses, but as MOOC they are open and accessible to anyone. The same can be said of the K-MOOC platform in Korea, established in 2015 with the government support and operated since then by the National Institute for Lifelong Education (NILE). The most well-known MOOC platforms like Coursera and edX in the United States provide accessible and free-of-charge courses, though in principle, they are commercial ventures by private US universities.

Public curation of digital teaching and learning resources

Another, more targeted and controlled way for countries and jurisdictions to provide digital teaching and learning resources is to operate online educational platforms. On those platforms, countries and jurisdictions can select, host, curate and deliver a range of educational resources, developed in-house by national education agencies, or provided by various public and private stakeholders. Those resources are generally more aligned with central or jurisdictional curricula.

Online educational platforms offer more control to public educational authorities over the resources they host than, for instance, TV and radio broadcast, in the sense that their access and use can be made exclusive to certain groups of people. Typically, a student or teacher credential can be required to sign up on such platforms and access parts (or the whole) of the content they host. This is a way to restrict access to educational contents to the cohorts of students they cater for, or to house copyrighted and proprietary content with specific usage limitations.

Nonetheless, online educational platforms may also host contents that are available to anyone, enrolled in formal education or not. This would be the case of Open Educational Resources (OER) for instance, as discussed below.

Out of the 29 countries and jurisdictions for which we have comparative information, all but the Netherlands, Sweden and the United States publicly provide teaching and learning resources through some types of online educational platforms. This is not to say that digital teaching and learning resources are not available in those three countries though. In the Netherlands, schools directly choose what teaching and learning resources they want to licence, with public funding but under minimal involvement of the central government. In Sweden and in the United States, it would be the role of local levels of government, respectively municipalities and school districts, to provide their schools with resources that pertain to teaching and learning. Table 5.2 below provides an overview of the central and jurisdictional provision of digital teaching and learning resources through educational platforms and their types.

Table 5.2. Public provision of teaching and learning resources through online platforms (2024)

	Central provision	Resources in open access (e.g. OER)	Types of resources provided				Examples of platforms, catalogues, banks, etc.
			Static resources	Interactive resources	Resources for students with special needs	Self-assessment resources	
Austria	✓	✓	✓	✓	✓	✓	Eduthek, EduTube
Brazil	✓		✓	✓		✓	Plataforma Integrada MEC RED, Guia EduTech
Canada	✓*	✓*	✓	✓			L'École Ouverte, Ma Classe (Québec), Edonline (Saskatchewan), Virtual Learning Centre (New Brunswick)
Chile	✓	✓	✓	✓	✓	✓	Biblioteca Digital Escolar, Currículum Nacional
Czechia	✓	✓	✓			✓	iMyšlení, Metodický portal RVP, Evaldo
Denmark	✓	✓	✓			✓	Emu, Prøvebanken
Estonia	✓	✓	✓	✓	✓	✓	EIS (Eksamite Infosüsteem), E-koolikott
Finland	✓	✓	✓				Aoe.fi (Library of Open Educational Resources)
France	✓	✓	✓	✓	✓	✓	Lumni, Banks of Educational Digital Resources (BRNE); Pix
Hungary	✓	✓	✓	✓	✓	✓	National Public Education Portal (NKP)
Iceland	✓		✓	✓			Skólavefurinn
Ireland	✓		✓	✓	✓	✓	Scoilnet, Webwise
Italy	✓	✓	✓			✓	Scuola2030, INVALSI (website)
Japan	✓		✓			✓	MEXCBT, STEAM Library
Korea	✓		✓	✓	✓	✓*	ITDA
Latvia	✓	✓	✓	✓	✓	✓	Tavaklase.lv; Mape.skola2030.lv; MyDigiSkills
Lithuania	✓	✓	✓	✓	✓	✓	Svietimo Portalas; Informacinę testavimo sistemą
Luxembourg	✓		✓	✓	✓	✓	Schouldoheem.lu
Mexico	✓	✓	✓	✓	✓		Aprende en Casa, Maestros y Maestras en Casa
Netherlands							
New Zealand	✓	✓	✓			✓	Tāhūrangi; Te Waharoa Ararau;
Slovenia	✓	✓	✓	✓			Slovensko izobrazevalno omrežje

	Central provision	Resources in open access (e.g. OER)	Types of resources provided				Examples of platforms, catalogues, banks, etc.
			Static resources	Interactive resources	Resources for students with special needs	Self-assessment resources	
Spain	✓	✓	✓	✓	✓	✓	EDIA, Procomún and Agrega
Sweden							
Türkiye	✓	✓	✓	✓			Eğitim Bilişim Ağı (EBA)
United States							
England (United Kingdom)	✓	✓	✓	✓	✓	✓	Oak National Academy
Flemish Comm. (Belgium)	✓	✓	✓	✓	✓	✓	KlasCement, Het Archief voor Onderwijs
French Comm. (Belgium)	✓		✓	✓	✓	✓	e-classe, Happi, Pix
Total (29)	**26**	**19**	**26**	**20**	**15**	**20**	**/**

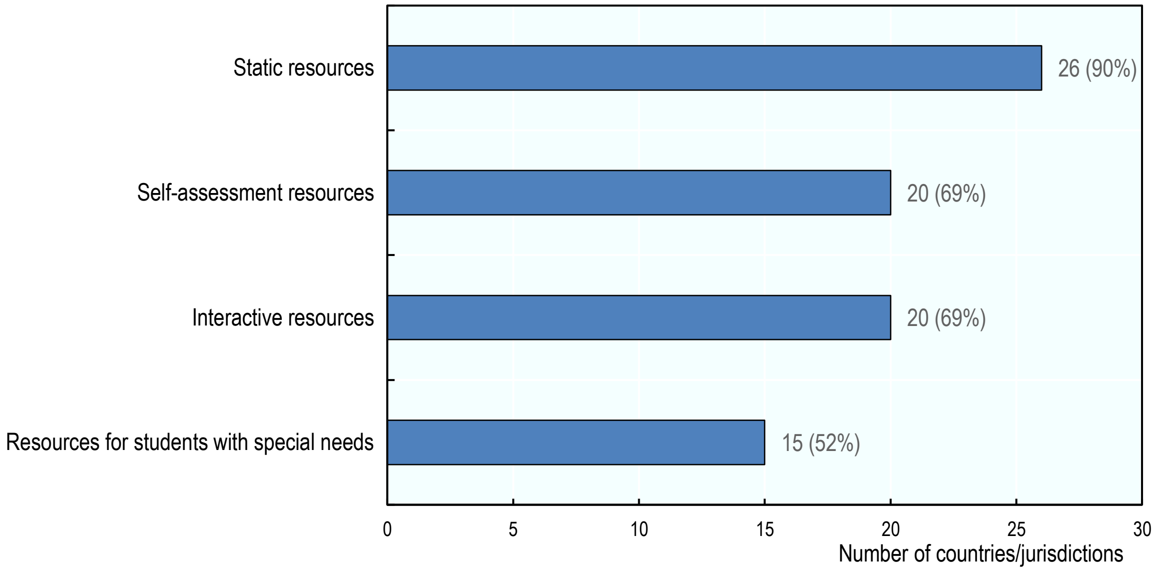
Note: In Canada, most provinces and territories maintain online educational platforms. In the Netherlands, Sweden, and the United States, providing schools, teachers and students with digital teaching and learning resources is the responsibility of local authorities, respectively schools, municipalities, and school districts.

StatLink https://stat.link/7myqzr

Resources in all shapes and forms

In every country and jurisdiction where an online education platform is provided from the central or jurisdictional level (26 out of 29), that is, almost everywhere, the platform curates static learning resources, which encompass digital textbooks, audio and video contents, one-way simulations or tests, research papers, etc (see Figure 5.2). They represent the most common type of digital learning resources, as they are often simply the result of the digitisation of paper-based learning resources. Examples of such resources abound on nationally maintained educational platforms. In Japan for instance, the Ministry of Economy, Trade and Industry (METI) maintains the STEAM Library, a comprehensive repository of educational materials that are freely accessible to students, teachers, and parents, serving both classroom learning and self-study at home. In Luxembourg, Schouldoheem.lu, a platform established during the pandemic, provides a wealth of learning resources in five different languages (Luxembourgish, French, and German, as well as English and occasionally Portuguese) to meet the specific needs of the country's school population and the requirements of the curriculum, covering a variety of subjects at all levels of education.

Figure 5.2. Types of teaching and learning resources publicly provided through online platforms managed from the central/jurisdictional level (2024)



Note: In Canada, jurisdictional authorities (provinces and territories) maintain online educational platforms. N=29.

StatLink https://stat.link/5qgud7

A majority of countries and jurisdictions (20 out of 29) have also developed or procure interactive learning resources that they make available to teachers and students. This typically refers to personalised learning resources that adapt to the learner and his or her interaction and progress with the content. They can be games, simulations, dynamic quizzes, or more advanced materials powered by algorithms or AI features. For instance, Austria's administers Eduthek, a platform that offers an array of digital educational resources including apps and games for all educational levels, from pre-primary to upper secondary education. Those resources are the products of collaboration between public and private sectors, coordinated and curated by the federal ministry of education on the Eduthek platform.

About half of the countries and jurisdictions (15 out of 29) reported that parts of the teaching and learning resources are made accessible to students with special needs or that they directly cater for students with special education needs. This was notably a priority objective of the Turkish Digital Education Platform ("*Eğitim Bilişim Ağı*", or EBA) during the COVID-19 crisis. In 2020, EBA host about 1 060 courses accessible to both students and teachers. The platform was instrumental to ensure educational continuity throughout the country, and particular attention was given to students enrolled in special education programmes. Video contents were translated into sign language and audio descriptions prepared for visually impaired students and made available through a specific app designed for students with special needs (Vidal, 2022[2]). EBA also provides an interactive learning environment in which students can attend live lessons, engage in online discussions, and receive feedback from teachers on their assignments. Teachers can create custom lessons, assign homework, and grade assignments in real-time, and parental access is allowed to monitor their students' academic progress. Within the platform, learning resources are mapped against the Turkish curriculum, making it easier for teachers and students to find relevant materials. Chile's *Educación Especial* repository also caters to students with special needs, offering resources like large-print textbooks for students with vision impairment, as well as other assistive technologies). In Ireland's, the National Council for Special Education supplying diverse tools and resources for inclusive education. This includes a curated list a recommended tools (such as apps for vision impaired or dyslexic students), video tutorials for supporting parents and teachers, and dedicated applications for the purchase of inclusive technology for schools. In the United States, although the federal government is not responsible for providing teaching and learning resources to schools, teachers and students, it requires that the resources procured by school districts are accessible by students with special needs. Numerous examples of private providers have thus developed solutions that work for all students. Tools like Ghotit's Real Writer and Reader, and Texthelp's Read&Write, cater to learners with dyslexia, dysgraphia, and other learning disabilities by offering advanced features, such as text-to-speech and word prediction. Kurzweil Education extends a suite of tools to students with learning and visual impairments, integrating assistive technologies that enhance content access and processing.

Countries and jurisdictions mobilise resources from different sources and origins. Some countries centralise open-licensed resources in catalogues, aiding teachers and students finding the materials they may need, as exemplified by the Czechia's Katalog EMA. This catalogue also ranks resources according to their popularity and quality to help teachers find useful resources to meet their needs. Countries may also procure resources from commercial providers. This is typically the case with digital textbooks, as detailed in the dedicated section below, but also for other types of resources. Japan's Surara Drill, an AI-powered adaptative lesson drill, and Luxembourg's MathemaTIC, a personalised learning platform for studying mathematics, exemplify the public procurement of privately developed resources. Finally, countries and their education agencies develop their own teaching and learning resources.

Among the five federal countries for which we have comparative information, only Austria operates an online educational platform from the federal level. This might attribute to the fact that the resources curated on such platforms are typically mapped to a curriculum, which may vary across provinces, territories, and states in a federation. While Austria, Brazil, and Mexico have a national curriculum, the responsibility for the actual implementation of curriculum in Brazil is decentralised, while in Mexico, the state-level governments have autonomy to adapt the curriculum to better fit their own contexts. Meanwhile, Canada and the United States have no federal curriculum, which reduces incentives to provide a national educational platform. Austria's public educational platform, edutube, is comparatively narrower in focus than other national platforms, storing educational videos such as documentaries and movies that teachers can use for teaching purposes.

In countries and jurisdictions that use educational taxonomies, publicly provided or procured digital resources are systematically categorised and possibly mapped against the relevant curriculum, easing the search for specific materials (see (Vincent-Lancrin and González-Sancho, 2023[3])).

Open educational resources

About to two thirds of countries and jurisdictions (19 out of 29) curate open educational resources (OER), through their usual educational platforms or through dedicated repositories.

The Flemish Community of Belgium's KlasCement, Brazil's Plataforma Integrada MEC RED, England's Oak National Academy, France's Lumni platform, and Lithuania's Svietimo Portalas are some examples of repositories specifically designed to host OER that can be accessed and used by anyone in the country. Similarly to their closed-access counterparts, the types of resources they host vary from countries to countries, but they typically range from static resources like lessons, video and audio clips and academic articles, to more interactive ones that allow for more active learning.

OER repositories can be set up by public agencies or through public partnerships. Spain's EDIA repository is founded by a collaboration between the central ministry of education and regional ministry of Extremadura. In France, the establishment of the Lumni platform involved the education ministry, and other governmental agencies, but also public broadcasters, i.e. France Télévision and Radio France.

While federal countries rarely curate closed-access educational platforms tailored to support the needs of teachers and students they are not directly responsible for, some of them do maintain catalogues or repositories of open educational resources. Again, this is sometimes a legacy of countries' response to the COVID-19 crisis when federal governments stepped up to support their jurisdictions in ensuring education continuity everywhere. In Mexico for instance, the federal government launched the "Aprende en Casa" ("Learning at home") programme to help teaching and learning continue despite school closures. Since then, resources were mapped against the national curriculum and are now available to Mexican citizens abroad.

Conversely, in others federal countries, curating open educational resources is left to the discretion of sub-governmental jurisdictions. In Canada, Quebec's Open School ("L'École Ouverte"), for example, is provincially curated to align with the province curriculum, even though some of the materials are openly accessible country wide.

In the United States, the OER landscape is primarily shaped by non-governmental organisations and philanthropic efforts. The Institute for the Study of Knowledge Management in Education's (ISKME) OER Commons platform (funded mainly by philanthropic foundations and donations like the William and Flora Hewlett Foundation) and the Massachusetts Institute of Technology's (MIT) Open Courseware are prominent examples of such initiatives.

Self-assessment resources

In the context of this report, self-assessment resources refer to (banks of) assessment items that can be accessed and taken by individual students or teachers to assess their own skills. They are therefore treated as learning resources and are distinguished from national evaluations and end-of-course exams. (For more details about the digitalisation of those types of assessment, see (Vidal, 2023[4])). However, some items from past evaluations or exams may be reused and added to banks of self-assessment resources.

Out of the 29 education countries/jurisdictions surveyed, 20 provide students and teachers with self-assessment resources. They are sometimes provided by sub-governmental authorities, as illustrated by the self-assessment platform offered by the Gyeongsangbuk-do province in Korea.

Similarly to OER, self-assessment resources may be curated alongside other types of learning resources on online educational platforms. However, at least nine countries and jurisdictions provide their students with separated self-assessment platforms. In Denmark, the Prøvebanken ("Test bank") is geared towards exam preparation, providing resources like sample exercises from the National Tests (Danish standardised student evaluation), and other resources that teachers can use to prepare assessments and that students can use to test their skills and knowledge in various subjects. In Lithuania, the ministry provides a digital self-assessment system, "Informacinę testavimo sistemą", with resources for a broad range of subjects (e.g. mathematics, languages, history, biology, information technology), but also support tools for students with disabilities.

Beyond helping students prepare for their exams, countries and jurisdictions encourage the use of self-assessment platforms in teaching and learning. Japan is an exemplary case. The ministry of education has endorsed the use of MEXCBT, a computer-based assessment system, for a broad range of applications, from students' self-assessment of knowledge in fundamental subjects (e.g. mathematics, Japanese, and English) to classroom use, as well as for nationwide academic achievement and learning situation surveys.

In several countries and jurisdictions, self-assessment platforms are specifically geared to measure digital literacy. France and the French Community of Belgium recommend the use of *Pix*, an open-source, free platform developed by the French ministry of education for self-assessing digital skills. *Pix* provides self-assessment tailored to both students and teachers and is available to the general public. Other countries, like Austria, Czechia, and Estonia, have created self-assessment resources aligned with the European

Digital Competence Framework (DigComp). For example, students and teachers in Austria can voluntarily use the digi.check platform to assess their digital skills and identify areas for further development. Similarly, in Czechia, *Profil Učitel21* and *Evaldo* are two platforms that are available respectively for teachers and the general public to evaluate their digital competences. In Estonia, an online self-assessment questionnaire was developed based on the DigComp for Educators (DigCompEdu) framework for teachers to assess their own digital competences. Outside of the European Union, Brazil has developed its own self-assessment tools for digital competence through a collaborative effort between the Innovation Centre for Brazilian Education, a non-profit association, and government bodies, that teachers can access upon registration on the *Guia EduTec* portal.

Digital textbooks

Out of 29 education countries and jurisdictions for which we have comparative information, almost two thirds (18) report that their schools have access to digital textbooks: Austria, Brazil, Canada, Chile, Estonia, Finland, Hungary, Ireland, Italy, Japan, Korea, Lithuania, Luxembourg, Mexico, Slovenia, Sweden, Türkiye, and the United States. While digital textbooks are widely available, schools retain autonomy to choose whether, or which, digital textbooks they would use.

In countries where digital textbooks are commonly available, degrees of procurement centralisation and funding mechanisms vary significantly. Hungary is a rare example where the Educational Authority, a central government agency, stands as the primary textbook publisher. This approach is distinct from most other OECD countries where textbook publishing is typically a role for private publishers (although often with significant government regulation, approval processes, or co-ordination). For example, in Estonia, digital and physical textbooks are developed by private vendors, they undergo evaluation by teachers, lecturers, and other experts, and adhere to the criteria outlined in the relevant regulation. A similar picture is illustrated in Austria, Brazil, and Japan, where publishers and booksellers develop both digital and physical textbooks, and the ones that meet the set criteria and pass the quality assurance process set by the education ministry become available for schools. In Mexico, (digital) textbooks are procured and made available for free by a national commission (CONALITEG).

Conversely, in Nordic countries (Denmark, Finland, and Sweden) and federal countries where education governance is wholly or partly decentralised to states, provinces, or municipalities, textbook procurement (including digital ones) is the responsibility of the relevant sub-governmental authorities. Schools retain autonomy to choose and use digital textbooks, yet sub-governmental authorities provide funding, and sometimes set agreements or frameworks with publishers for the supply of (digital) textbooks to the schools within their area.

Reflecting on the benefits of flexibility, accessibility, and personalisation, numerous countries are actively enhancing the interactive features enabled by digital textbooks (see Box 5.1). As of 2024 though, most efforts are geared towards ensuring that textbooks are accessible to students with special needs.

Countries that centrally procure digital textbooks have also explored how they could integrate them into their ecosystem of digital tools and resources. In Türkiye, the digital textbooks are accessible through e-Okul, the publicly developed and provided learning management system that also serves as a repository of learning resources and whose use is fostered in all schools of the country. In other countries, the digital textbooks are catalogued alongside other learning resources on online educational platforms, as is the case with Edunet T-Clear in Korea.

As is the case with most other types of digital teaching and learning resources, few surveys about the use of digital textbooks have been conducted across OECD countries. Where they exist, they indicate varied adoption rates. In Japan, digital textbooks for certain subject (e.g. English) are provided by the education ministry to all primary and lower secondary schools with a moderate uptake (36.1% of public schools in 2022). In the United States, a substantially higher uptake was reported in 2020 (half of public schools). In Finland, a significant portion of textbooks are digital, with substantially higher use reported in Helsinki.

According to the Finnish Publishers Association, nearly 80% of textbooks are digital in upper secondary education. In Türkiye, digital textbooks for vocational training are provided to all students with a view to provide remote VET education, as exemplified by the Open Vocational High School initiative.

Box 5.1. The use of interactive digital textbooks for adaptive learning

Interactive digital textbooks represent a transformative step in educational resources, infusing traditional learning materials with technology to create dynamic, personalised educational experiences. Incorporating multimedia elements and adaptive features, interactive textbooks cannot be compared with digital textbooks that would merely be the result of the digitisation of traditional textbooks. .

Interactive textbooks offer a dynamic and immersive learning experience by introducing diverse and personalised learning materials (Gottschalk and Weise, 2023[5]). Their digital format also allows for swift updates, ensuring that the material remains contemporary and pertinent. Nevertheless, cost remains a barrier to accessibility, echoing challenges similar to those with traditional textbooks (OECD, 2021[6]). The cost factor may inhibit some students from accessing these resources, leading to potential exclusion in systems that have fully transitioned to digital textbooks.

The integration of adaptive learning technology is a standout feature, enabling the customisation of content and pacing to match individual student needs and performance metrics. Additionally, interactive digital textbooks often provide functionalities for annotations and note-taking, allowing students to engage actively with the material. These resources further facilitate collaborative learning through features like shared notes and discussion forums.

Interactive digital textbooks are adopted and used in several OECD countries, such as Finland, Korea, and the United States. In Korea, interactive textbooks are provided on Edunet T-Clear, the country's national teaching and learning platform. Not only they provide a variety of interactive and adaptable learning materials, but they are also interoperable with other Edunet T-Clear-based platforms, and can thus be accessible through a single sign on (SSO) service. In Finland, educational publishers such as Sanoma Pro and Otava Oppimisen Palvelut provide a wide array of digital learning materials, including interactive digital textbooks. Their digital books feature videos, animations, self-assessments, and interactive exercises that complement the Finnish curriculum. In the United States, McGraw Hill Education, Pearson, and Cengage Learning are the example companies that provide interactive digital textbooks at different levels of education. Like other examples, they provide embedded assessment tools, interactive assignments, and personalised learning modules that adapt to the student's performance and understanding, providing real-time feedback and assistance.

Public provision of "smart" digital tools and resources

Beyond static and interactive digital resources, a new class of smart tools and resources are now available. They are usually powered by different types of AI-based algorithms. These teaching and learning resources are comprised of adaptive learning systems, including intelligent tutoring systems (Molenaar, 2021[7]), digital systems and techniques that aim to keep students engaged in their learning (D'Mello, 2021[8]), adaptive assessments that adapt to the level or observed difficulties of students (Buckley et al., 2021[9]; Foster and Piacentini, 2023[10]) as well as social robots (Belpaeme and Tanaka, 2021[11]). Many other applications based on learning analytics are also available.

No country provides such resources publicly. However, there are two countries where adaptive learning systems, including intelligent tutoring systems, are commonly used in at least primary education: the Netherlands (Box 5.2) and the United States. Both in the Netherlands and in the United States, these solutions are procured with public funds, typically by schools themselves in the Netherlands, and by districts or municipalities in the United States, a bigger market, also known for its diversity. In the United States, adaptive learning systems and intelligent tutoring systems are also relatively common, notably to learn mathematics and English.

Another group of smart digital resources are meant to support teachers directly (rather than students under the supervision of teachers). They take the "classroom" as their unit of analysis (Dillenbourg, 2021[12]). They provide teachers with hints on how to orchestrate their teaching in real time (for example who needs help, how to form groups within class, when to transition to another activity when a group works on the same task individually, whether the class is still engaged, etc.) or provide them with feedback on their teaching practices (how long they speak compared to students, where they move in the classroom, what mix of educational activities they have during their lessons, etc.).

No country among our respondents provided such tool as part of their publicly provided teaching and learning resources platforms. Most respondents had no awareness of these tools, and when informed, none reported these tools were mainly used for research and development (or marginally). These digital tools hold great promise to support teachers, but they also raise significant privacy and ethical challenges that need to be addressed and balanced against their potential benefits. Other, more analogic approaches to "smart classrooms" are being pioneered in a few countries though (Box 5.3).

All these technologies based on AI can be interpreted thanks to the "detect, diagnose, act" model developed by Molenaar (2021[7]): detecting consists of capturing relevant information; diagnosing, of analysing the information to determine between different possible interventions; and acting of making a suggestion or taking an action. Typically, depending on the tool and the context, these models will involve different levels of human intervention (and of automation).

Box 5.2. Intelligent Tutoring Systems in the Netherlands

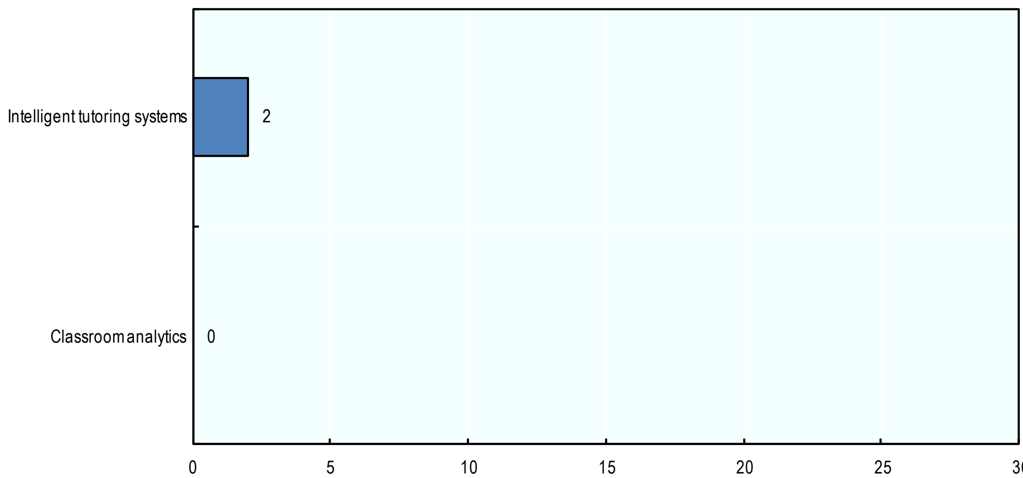
Intelligent Tutoring Systems (ITS) utilise AI technology to provide adaptive, personalised learning experiences. Although their prevalence varies (and remain relatively low on average) among OECD countries, they are becoming more common. The Dutch education system has embraced various ITS developed by companies such as Kurve (formerly Muiswerk Educatief), Prowise Learn, and Snappet, primarily for Dutch language and mathematics. Snappet, which is popular in primary education, crafts adaptable lessons from the analysis of student workbooks and inputs from teachers across the country. It supports interactive teaching, immediate feedback, and varied tasks for different skill levels. In addition, applications like Flexi (developed by Kurve), Rekentuin, Taalzee, and Words&Birds (developed by Prowise Learn) employ advanced algorithms and data-driven analysis to provide students with customisable exercises, extensive instructional materials, progress tracking, and direct feedback, so students can benefit from access to exercises tailored to their skill level and real-time error correction.

Dedicated AI in education technology remains in the planning stages in most countries – event though generative AI emerged in education as a general-purpose technology. Several countries, including Austria, Korea, Luxembourg, and Türkiye, are pioneering intelligent tutoring systems. Alongside these developments, there is an emerging focus on cultivating AI literacy among students, with initiatives underway in Austria and Korea to educate students on the fundamentals of AI, its societal impacts, and the attendant risks and benefits.

The emergence of generative AI, notably large language models such as GPT, has been disruptive to some traditional education models (such as exams, homework, etc.) This is discussed in a separate chapter. While generative AI is and can be used to support teaching and learning as a general purpose technology, policy makers should keep in mind that many other AI applications can support teaching and learning in education – and were designed for that very purpose.

As countries grapple with understanding the appropriate uses of AI for teaching and learning, how this affects teachers' roles, what usage by teachers and students should be encouraged or discouraged, they need to keep an open mind and strike a good balance between avoiding the possible pitfalls of AI and the promises it holds for the personalisation of learning and student performance. To catalyse these efforts, an intensification of international co-operation and the sharing of best practices will be crucial.

Figure 5.3. Number of countries where some smart technology is common (2024)



Note: According to government officials, intelligent tutoring systems are commonly used in the Netherlands and in the United States. N=29.

StatLink https://stat.link/2pgjyv

Box 5.3. A case of future technology: Aulas del Futuro project in Spain

The Aulas del Futuro (Classrooms of the Future) project in Spain represents a forward-thinking approach towards education, embracing the potential of technology to enhance learning experiences in educational spaces. This initiative, coordinated by the National Institute of Educational Technologies and Teacher Training (INTEF) in collaboration with autonomous communities, officially began in 2017, led by the Spanish Ministry of Education, Culture, and Sport.

The project represents not only a technological, but also a pedagogical innovation. It transforms traditional classrooms into dynamic, segmented areas designed for active learning, with zones named *Investigate, Explore, Interact, Develop, Create,* and *Present*. These spaces, featuring advanced tools such as digital boards, touchscreens, and Virtual Reality glasses, reposition the teacher's role to that of a guide and facilitator, promoting student engagement and accommodating various learning styles and paces.

This initiative blurs the distinction between physical and digital methodologies. It is in line with current educational research advocating for active, personalised, and technology-enhanced learning. To achieve official recognition from the ministry of education, schools must adhere to specific criteria, including active learning techniques, digital technology use, teacher participation, and integration with the school community. By so doing, the Aulas del Futuro project aims to foster comprehensive student development in a hybrid learning space that bridges the physical and digital realms.

Source: https://it3d.com/en/agreement-between-it3d-group-and-the-ministry-of-education-and-professional-training/

Online student tutoring platform

The COVID-19 pandemic has made the importance of tutoring visible, acknowledging strong evidence about the impact of individual or small-group tutoring. While intelligent tutoring systems put this partially in the hands of computers, several countries use technology to match human tutors and students. There are of course an abundance of private platforms doing so, but a few countries do also provide them as part of their public education. For example, recognising the imperative for supplemental educational support, the French Community of Belgium, New Zealand, and Spain have launched online tutoring services. These platforms facilitate teacher-student connections for home-schooled or internationally-based pupils.

Spain's approach allows for asynchronous activity completion with periodic teacher evaluations, supplemented by occasional live tutoring. In New Zealand, Te Kura, established in the 1920s as a correspondence school and backed since then by the education ministry, now offers personalised distance learning options, providing flexible enrolment and a blend of online and offline teaching from accredited educators. In the French Community of Belgium, the e-learning platform proposes online tutoring service for home-schooled students that matches teachers with students from primary through to secondary education.

While not as prevalent in all countries, these systems reflect a commitment to student success and are a promising part of to the evolving landscape of digital education.

Digital resources for teacher development

While students are the primary learners within an education system, it is also crucial to support teachers' professional learning. Part of the learning resources for students can also be (or are also) digital resources for their teaching. A different way to support their learning is to provide them with digital platforms with learning resources. This section highlights how countries support teachers' teaching by providing them with digital resources designed for them as resources to integrate in their lessons. In some cases, the resources can be about teaching with digital tools and a way to enhance their technology-related pedagogical knowledge (see (Foster, 2023[13]) on incentives to enhance teachers' digital competences).

Most countries provide publicly digital resources to support the teaching or professional development of their teachers, either nationally or at the sub-governmental level. Twenty countries and jurisdictions (out of 29, that is about two thirds) have a direct public provision of such resources (see Figure 5.4 and Table 5.3).

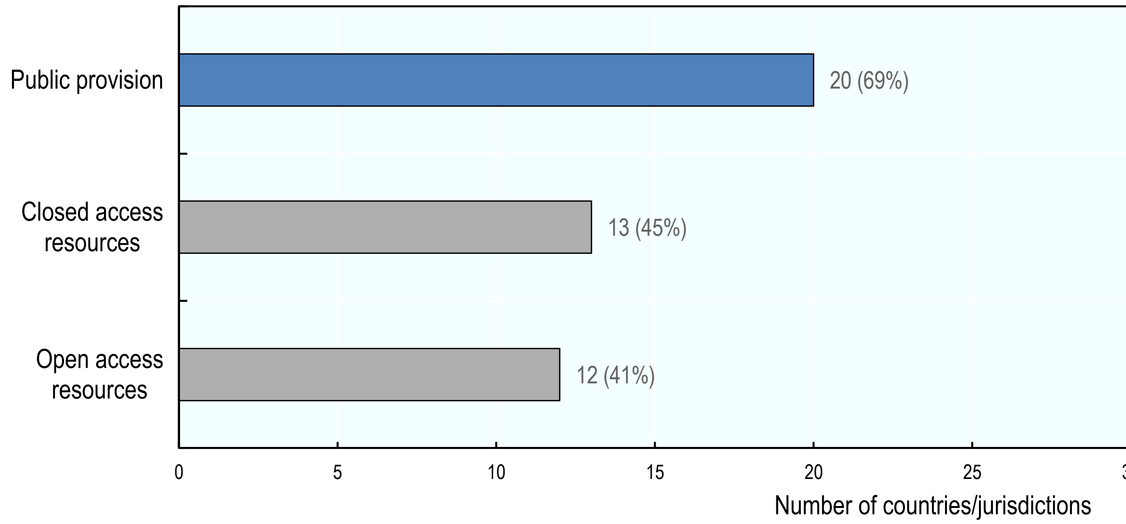
Around one third (13) of countries provide the resources as open-access resources, even though the materials specifically cater to educators' professional development. Those can take the form of instructional videos on YouTube (e.g. Estonia, Latvia), MOOC for teachers (e.g. Brazil, Mexico, Spain), and open-access portals offering various curriculum-aligned materials (e.g. England). Estonia's HARNO (*Haridus- ja Noorteamet*), an agency of the education ministry, manages a YouTube channel that features webinars and lessons pertaining to teaching methods, helping teachers seeking for professional development opportunities. Several public MOOC platforms are either dedicated to support teachers (e.g. TG22-AVAMEC for general education teachers and PlaforEDU for VET teachers in Brazil) or include dedicated sections for teachers (MexicoX in Mexico or aprendeINTEF in Spain). Finally, the BBC Teach website, run by the country's public broadcaster BBC, provides universally accessible resources that primarily supports teachers by curating curriculum-related content for the classroom. Another example is Denmark's Emu, the education ministry's online platform on which educators can find teaching resources and activities, exemplars of pedagogical practices, as well as templates for research papers and legal guidelines for the use of resources.

Countries provide closed-access resources for teachers, that is, resources that are only accessible to teachers formally enrolled in the system. This type of provision allows teachers to access commercially licensed resources. Some countries (e.g. Estonia and Sweden) provide both open and closed-access resources for teacher development. Those platforms typically include two types of resources: some for general education (with or without digital resources and tools) and resources to enhance teachers' digital competences.

Teacher training and development portals offer a suite of developmental tools for educators, such as for developing digital skills and competency. For instance, the Flemish Community of Belgium provides a ministry-developed online platform called Digisnap, based on the EU's SELFIE tool, giving teachers insights on their digital competences and allowing school leaders to set up tailored development plans. Digi.folio, an Austrian online platform for teacher development, maps training measures in the area of digital competences for teachers. Chile's "*Desarollo docente en linea*" portal offers tutors and courses directed at teachers reaching diverse facets of the teaching profession. The access to this portal is restricted to enrolled teachers. More resources focusing on teacher development are also available on "EducarChile", a teaching and learning platform open to everyone. Réseau CANOPÉ ("CANOPÉ Network") in France provides a diverse array of resources that cover a wide range of areas pertaining to teaching, from in-service teacher training and tutoring to best teaching practices, podcasts, and the history of education in the country. In Sweden, the National Agency for Education's website features a catalogue that includes a variety of inspirational and support materials for teaching, a significant portion of which specifically focus on the use of digital tools in education.

Finally, a third type of platforms is about peer-based learning and networking opportunities. Korea's Jisik Saemteo ("Knowledge Spring") and Sweden's SYV allow teachers to voluntarily share materials and receive peer feedback with other registered teachers. Those platforms are publicly maintained. Yet, these portals also extend to pedagogical and curriculum-related expertise. Additionally, while not managed at the national level, Manitoba (Canada) runs Maple ("Manitoba Professional Learning Environment"), an online community of teachers and school staff in Manitoba for exchanging ideas, receiving support and relevant information.

Figure 5.4. A snapshot of the public provision of digital resources for teacher development (2024)



Note: Public provision is noted for central and sub-governmental levels (when typical at the sub-governmental level). Closed and open access resources are not mutually exclusive. N=29.

StatLink https://stat.link/6ilsm1

Table 5.3. Public provision of digital resources for teacher professional development (2024)

	Public provision at central level or sub-governmental level	Open access resources	Closed-access resources
Austria	✓		✓
Brazil		✓	
Canada	✓		✓
Chile	✓	✓	✓
Czechia			
Denmark	✓	✓	
Estonia	✓	✓	✓
Finland		✓	
France	✓		
Hungary	✓		
Iceland	✓		
Ireland	✓	✓	
Italy	✓		✓
Japan	✓		✓
Korea	✓		✓
Latvia	✓	✓	
Lithuania	✓		✓
Luxembourg			
Mexico	✓	✓	
Netherlands			
New Zealand	✓	✓	✓
Slovenia			
Spain	✓	✓	

	Public provision at central level or sub-governmental level	Open access resources	Closed-access resources
Sweden		✓	✓
Türkiye	✓		✓
United States			
England (United Kingdom)		✓	
Flemish Comm. (Belgium)	✓		✓
French Comm. (Belgium)	✓		✓
Total (29)	**20**	**12**	**13**

Note: Public provision is national/central in all countries/jurisdictions, except in Canada where it is common to provide teacher digital resources at the provincial level. N=29.

StatLink https://stat.link/ft9q6y

Moving forward: key insights, reflection, and possible development

Summary of findings

As of 2024, the public provision of digital teaching and learning resources has become a responsibility commonly assumed by most central and jurisdictional authorities (European Commission, Directorate-General for Education, Youth, Sport and Culture, 2023[14]). Countries and jurisdictions develop, mobilise, and procure different types of resources and leverage different modes of delivery. In most places, and often as a result of mitigation measures put in place during the COVID-19 pandemic to ensure education continuity through remote learning, countries and jurisdictions provide educational content through open channels. This includes public TV and radio broadcasts (also streamed on-line for replay) in 24 countries and jurisdictions; but also educational content channelled through social media run by governments, typically on YouTube, in up to 13 countries. Eight countries maintain national MOOC platforms that offer teaching and learning resources available for anyone, while such platforms are traditionally operated by higher education institutions or commercial providers.

Most countries and jurisdictions also publicly provide teaching and learning resources in a more controlled and targeted mode, often aligned with their curriculum, and typically curated on online educational platforms. Though those platforms may also curate open educational resources (OER), in practice most or all of their content is accessible to those who are enrolled in the formal education system only. Apart from the Netherlands, Sweden, and the United States, national or jurisdictional education authorities maintain such platforms to catalogue and curate static (all 26 countries) and interactive (20) resources, inclusive of self-assessment resources (20) and accessible for students with special needs (15). Digital textbooks are also procured in 18 countries and jurisdictions, and sometimes feature interactive contents. But as of 2024, no country publicly provides the most advanced types of digital resources, such as intelligent tutoring systems or classroom analytics software.

Beyond teaching and learning resources, our comparative analysis further indicates that 20 countries and jurisdictions directly provide digital resources for teacher development, some of which are specifically aimed at advancing teachers' digital literacy and fostering their efficacy in teaching with or about digital tools. Finally, 3 central or jurisdictional authorities have set up online student tutoring platforms that facilitate the matching of students with tutors for supplemental educational support, for instance for home-schooled or international-based students.

Looking forward: where to go next?

Making digital resources available to students and learners

Digital learning resources are either publicly provided or procured with public funds in all countries. Some countries provide some open educational resources, available to the general population. This is particularly important to support lifelong learning and try to equalise opportunities across learners within a country. Most digital learning resources aligned with the curriculum are provided according to the closed-access model (giving access to students and teachers enrolled in the system, and sometimes just for given years). This reflects that these publicly provided resources are licensed from publishers and charged according to use. This is also a way to better protect their intellectual property. However, most digital platforms also include open educational resources.

Countries use different models of provision. Some countries provide a bank of digital learning resources nationally: they are the same for all teachers and learners, but are usually varied enough on any subject to allow teachers some choices. In some cases (e.g. France) they are supplemented by resources that are procured locally; in some cases (e.g. Korea) they represent the core of the resources available to teachers. The advantage of this system is to provide a common baseline to all teachers and learners. When resources are procured from commercial vendors, it also allows for a frequent renewal and update of the resources and possibly an acquisition at better price. The risks of such model are that the digital resources lack variety (and that teachers may not find them appropriate for their local uses) and that they are not easily connected to the diverse learning/content management systems of schools (unless interoperability standards make it possible).

If not at the national level, most countries either provide these resources at the sub-governmental level (municipalities, districts) or just let schools choose from an array of commercial resources themselves (usually procured though municipalities or local education authorities). To the extent that schools and municipalities are resourced enough, this allows context-appropriate digital learning resources to be available for teaching and learning, and also the chosen resources to be compatible with local learning management systems (if relevant). This devolution of responsibility could raise equity issues where procurement choices are based on local taxes rather than school funding mechanisms. One disadvantage of this model is that the resources may be more costly and also that they may be less carefully curated and selected compared to a procurement at governmental or sub-governmental level, assuming these levels have the expertise and resources to do a good curation.

While these models usually follow pre-existing policies in terms of devolution of responsibility, it is noteworthy that some digital learning resources could be dealt with in a different way, especially when they are expensive by school budget standards. Countries have to balance the advantages and disadvantages of the different models given their context and the access issues they have to address.

Going from availability to use

While most countries estimate that a majority of their schools have access to and frequently utilise digital teaching and learning resources, the extent and effectiveness of this usage vary significantly. There is in fact very limited information on their use and while most students and teachers use digital learning resources from time to time, non-digital resources are still the main learning resources used by students and teachers in most countries. The pandemic also highlighted that even in countries where digital learning resources were centrally provided, those were not necessarily used.

There are different ways for governments to incentivise the use of digital learning resources, which are analysed in depth in other chapters of this report. One is to include some use of digital learning resources in the national or sub-governmental curriculum or to strengthen teachers' familiarity with and capacity to use digital learning resources as part of their teaching. As hinted above, another one lies in procurement:

it is likelier that teachers or schools will use resources that they choose to procure (if they have the propensity to use those resources).

One challenge also lies in the ease of access. Using too many digital platforms probably reduces the use of digital learning resources by learners and students. This makes the resources and platforms more difficult to find, and this implies that they are not necessarily seamlessly accessible from the other digital tools they use, notably their school learning management system. Countries have developed single sign-on solutions to limit the exchange of personal data with commercial vendors but also to make it easier to access a variety of platforms. Another effort lies in making digital learning resources interoperable with other digital tools within schools, and allow to use them in a possibly smarter way. Currently, the choice and use of those resources is only informed by teachers' knowledge. With more integration, teachers' decisions could be informed by recommendation tools taking into account information about their students.

One possible solution for countries to consider, regardless of the provision model, would be to provide a platform for commercial (and governmental) publishers, which would provide incentives to publishers and tool developers to respect some interoperability standards (and other requirements).

Going from digital to smart resources

Presently, the majority of resources remain static, such as (non-interactive) digital textbooks, video contents, and past exam questions, which may often merely transpose conventional chalk-and-board teaching methods to a digital format. Static digital resources will always keep a role in the education process, as is the case for physical, non-digital resources. However, the lack of engagement with smart digital learning resources may be a missed opportunity to provide more individualised teaching and learning. As of 2024, most digital learning resources provided and used in OECD schools are non-adaptive. Interactive digital textbooks are the most widely used "advanced" digital learning resources: they are more interactive and include exercises related to the lessons, etc., but they are still typically not adaptive. Intelligent tutoring systems, which could allow students to overcome some of their misconceptions and master procedural knowledge, are still rarely available and used within countries – not to mention other types of smart technology (OECD, 2021[15]).

The transformative potential of digital resources consists in their ability to move beyond the traditional linear approach towards an interactive, engaging and more individualised (though still social) educational experience. Governments should support schools and teachers to engage in this direction. While they have started to do so for generative AI applications, more awareness and guidance about digital learning resources and tools especially developed for education remains necessary.

Monitoring use and conditions of use

A final step would be to monitor and understand how digital learning resources are used by students and teachers, and what kind of uses are more effective for different students. Only a few countries have conducted studies or statistical analyses on the use of digital education. International surveys such as the OECD Programme on International Student Assessment (PISA) are often the main source of information about the uptake and use of technology in school and in the classroom (Vincent-Lancrin et al., 2019[16]).

Countries should develop a monitoring framework that would allow one to better understand effective uses of digital learning resources for different stages of formal (and informal) education. Some countries have specifically investigated the adoption and practical application of digital teaching and learning resources. These studies frequently reveal a disparity between the availability of digital resources and their actual use, with findings indicating under-utilisation or ineffective application. Research, monitoring and data collection efforts are necessary to better understanding how to make the best of digital learning resources. Countries could undertake or commission such research and coordinate it internationally.

References

Belpaeme, T. and F. Tanaka (2021), “Social Robots as educators”, in *OECD Digital Education Outlook 2021: Pushing the Frontiers with Artificial Intelligence, Blockchain and Robots*, OECD Publishing, Paris, https://doi.org/10.1787/1c3b1d56-en. [11]

Buckley, J.; L. Colosimo; R. Kantar; M. McCall and E. Snow (2021), “Game-based assessment for education”, in *OECD Digital Education Outlook 2021: Pushing the Frontiers with Artificial Intelligence, Blockchain and Robots*, OECD Publishing, https://doi.org/10.1787/9289cbfd-en. [9]

Dillenbourg, P. (2021), “Classroom analytics: Zooming out from a pupil to a classroom”, in *OECD Digital Education Outlook 2021: Pushing the Frontiers with Artificial Intelligence, Blockchain and Robots*, OECD Publishing, https://doi.org/10.1787/336f4ebf-en. [12]

D’Mello, S. (2021), “Improving student engagement in and with digital learning technologies”, in *OECD Digital Education Outlook 2021: Pushing the Frontiers with Artificial Intelligence, Blockchain and Robots*, OECD Publishing, https://doi.org/10.1787/8a451974-en. [8]

European Commission, Directorate-General for Education, Youth, Sport and Culture (2023), *Digital education content in the EU – State of play and policy options – Final report*, https://doi.org/10.2766/682645. [14]

Foster, N. (2023), “Teacher digital competences: formal approaches to their development”, in *OECD Digital Education Outlook 2023. Towards an Effective Digital Education Ecosystem*, OECD Publishing, https://doi.org/10.1787/c74f03de-en. [13]

Foster, N. and M. Piacentini (eds.) (2023), *Innovating Assessments to Measure and Support Complex Skills*, OECD Publishing, Paris, https://doi.org/10.1787/e5f3e341-en. [10]

Gottschalk, F. and C. Weise (2023), “Digital equity and inclusion in education: An overview of practice and policy in OECD countries”*, OECD Education Working Papers*, No. 299, OECD Publishing, Paris, https://doi.org/10.1787/7cb15030-en. [5]

Molenaar, I. (2021), “Personalisation of learning: Towards hybrid human-AI learning technologies”, in *OECD Digital Education Outlook 2021, Pushing the Frontiers with Artificial Intelligence, Blockchain and Robots*, OECD Publishing, https://doi.org/10.1787/589b283f-en. [7]

OECD (2023), *Country Digital Education Ecosystems and Governance. A companion to Digital Education Outlook 2023*, OECD Publishing, https://doi.org/10.1787/906134d4-en. [1]

OECD (2021), *Adapting Curriculum to Bridge Equity Gaps: Towards an Inclusive Curriculum*, OECD Publishing, Paris, https://doi.org/10.1787/6b49e118-en. [6]

OECD (2021), *OECD Digital Education Outlook 2021: Pushing the Frontiers with Artificial Intelligence, Blockchain and Robots*, OECD Publishing, Paris, https://doi.org/10.1787/589b283f-en. [15]

Vidal, Q. (2023), “Digital assessment”, in *OECD Digital Education Outlook. Towards an Effective Digital Education Ecosystem*, OECD Publishing, https://doi.org/10.1787/c74f03de-en. [4]

Vidal, Q. (2022), “Turkey: I am special, I am in education”, in *How Learning Continued during the COVID-19 Pandemic: Global Lessons from Initiatives to Support Learners and Teachers*, OECD Publishing, Paris, https://doi.org/10.1787/28bb8223-en. [2]

Vincent-Lancrin, S. and C. González-Sancho (2023), “Interoperability: unifying and maximising data reuse within digital education ecosystems”, in *OECD Digital Education Outlook 2023. Towards an Effective Digital Education Ecosystem*, OECD Publishing, https://doi.org/10.1787/c74f03de-en. [3]

Vincent-Lancrin, S.; J. Urgel; S. Kar and G. Jacotin (2019), *Measuring Innovation in Education 2019: What Has Changed in the Classroom?*, Educational Research and Innovation, OECD Publishing, Paris, https://doi.org/10.1787/9789264311671-en. [16]

6 Hardware: the provision of connectivity and digital devices

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Connectivity – meaning stable, reliable, and high-quality connection to the Internet – and digital devices are necessary, albeit not sufficient conditions to realise the full potential of digital education. Its large-scale provision, however, remains a challenge for education systems, a challenge that was simultaneously amplified and galvanised by the COVID-19 pandemic that forced a shift to remote learning. This chapter analyses where countries stood before the pandemic regarding the provision of connectivity and devices, which policies they implemented in past years, and what is coming next for systems aiming to bring digital education to schools and students everywhere.

Introduction

A reliable connection to online digital education resources and platforms and available and properly usable devices by students and teachers are key prerequisites for the access and full effectivity of digital education. Connectivity and access to digital devices stand as necessary, albeit not sufficient, conditions for the full potential of digital education and for the digital transformation of education. The provision of high-quality connectivity has been acknowledged by OECD member countries as an important factor for the digital transformation, a way to promote equity of opportunity and increased competitivity within economic actors (OECD, 2004[1]).

In education, the provision of Information and Communication Technology (ICT) infrastructure and the provision of adequate connectivity at schools are frequent education policy objectives worldwide. Their evident need appeals to governments aiming for broader digitalisation agendas and for keeping their economies and societies – including their education systems – competitive.

The significant disruption to education systems caused by the COVID-19 global pandemic galvanised governmental ICT initiatives. As schools closed and an unforeseen shift to remote or hybrid education was mandated, further investment and efforts towards the provision of connectivity and digital devices was urgent to assure the continuity of, and, in many cases, the basic access to education.

This chapter discusses how countries have worked, are working, and aim to work towards the objective of connecting students and schools everywhere in their jurisdictions, and to provide an adequate ICT infrastructure that allows schools and students everywhere to access the digital tools and resources that they need and, in some cases, to continue their learning wherever they may be. It concludes with a few remarks on potentialities and challenges ahead, as education systems aim to bring digital education to all.

High-quality connectivity to fully leverage digital education

Widespread and high-quality access to the Internet are indispensable conditions to leverage the full potential of digital education. Reliable connectivity is key for students to fully enjoy digital, personalised, and engaging learning through digital solutions, for them to communicate with their teachers or tutors, and to receive timely feedback on their activities. Furthermore, at the system level, reliable connections to the Internet are essential for the data environment that populate the education systems with a strong education data infrastructure.

In addition, the need for Internet connections that are more reliable, afford more speed, more bandwidth and less latency is likely to increase as digital solutions evolve. Real-time streaming of audio and video are now commonplace in the daily life of students and teachers, either through communication software (e.g. Microsoft Teams, Zoom), video repositories (e.g. YouTube), or Massive Online Open Course (MOOC) platforms. These activities involve a large amount of data being downloaded and uploaded, which in turn require considerable speed and bandwidth, while more widespread adoption of solutions based on Artificial Intelligence, such as intelligent tutoring systems, will require more agile (i.e., smaller latency) communications between students and wherever the solution is hosted.

Besides the access and quality of Internet connections for digital education in school, where education takes place has also become a concern. The increasing availability of digital devices in the classroom, either by broader distribution programmes (further discussed in this chapter) or by Bring Your Own Device (BYOD) policies, begs the question of "last mile" provision of connectivity. The reliable and safe set-up of these wireless networks capable of sustaining considerable simultaneous and high demanding connections and data exchanges induces, in turn, a need for dedicated physical infrastructure (e.g., higher throughput routers, servers), and Information and Communications Technology (ICT) expertise to set it up and support.

Moreover, the significant disruptions to in-school teaching and learning caused by the global pandemic have also shown that this “last mile” does not only encompass the classroom but may also extend as far as students’ homes and personal devices. During the period of remote learning caused by school closures, policy was put in place to subsidise mobile Internet connections for students to meet basic connectivity needs that might enjoy some continuity to support students without connections at home due to socio-economic conditions or remoteness. It became thus even clearer that high-quality connectivity is bound to play a role in fostering more equitable and resilient education systems (Principles for AI in Education).

Access and quality of connectivity at schools

Access to high-quality Internet, or at a more basic level, universal access to the Internet itself is still a challenge for schools worldwide both in developed and developing countries, albeit against a broader policy backdrop where OECD member countries committed at the government level to the provision of high-quality and affordable connectivity for all (“Cancún Declaration”: (OECD, 2016[2])).

Box 6.1. Access, even to limited ICT resources, cannot be taken for granted everywhere

A significant share of students does not have access to even a small number of Internet-ready computers in Brazil and Mexico as of 2018

There are yet no comprehensive international surveys of connectivity at schools worldwide, but data from the 2018 cycle of the Programme for International Student Assessment (PISA 2018) (2019[3]) can provide a limited baseline (being restricted to 15 year old students enrolled at lower or upper secondary education) of whether and how fast students had access to reliable Internet connections before the investments in infrastructure from the recent years during and in the aftermath of the COVID-19 pandemic.

PISA 2018 data shows that students had, among the 28 OECD Member countries that participated in this data collection plus Brazil, students were mostly enrolled in schools where at least 10 computers with Internet access were made available for use. This threshold was chosen as to represent the smallest average classroom size among participating countries in this student cohort, indicating whether classes could be entirely ministered using resources that relied on an Internet connection to function. [1]The rationale behind this choice is that, in the absence of digital resources to serve an entire classroom, teachers might be discouraged from brining the classroom in contact with the resources – and thus keeping students from accessing digital resources at all.

This lower bound for Internet availability at school is met in almost all participating countries, with the exception of Brazil and Mexico, where only 62.9% and 75.3% of students respectively were enrolled in schools with more than 10 computers connected to the Internet.

The Figure also indicates that this digital divide is amplified in the latter two countries by student socio-economic status, as measured by the Economic, Social, and Cultural Status (ESCS) in PISA. [2] Averages are indicated by the bars, while points indicate proportion for students in the lowest and highest ESCS quartiles, thus providing an indication of an access gap related to socio-economic status. Gaps are significant in Brazil and Mexico and particularly dramatic on the latter – while 90% of more socio-economically advantages (i.e., top quartile ESCS) Mexican students are enrolled in schools with some access to the Internet, this is only true for half of disadvantaged (i.e., bottom quartile ESCS) students.

Both countries are engaged in bridging this access gap. Access to high quality internet and its provision to schools is an axis of the government-wide Brazilian digitalisation strategy, and one of the goals of its education-focused digital education national policy, both of which foresee synergies with broader infrastructural, and education-specific projects. [3] Indeed, given Brazil's considerable geographical dimensions and diverse environments, the provision of reliable connectivity to schools is often included within the scope of broader infrastructure initiatives aiming to serve connectivity to the entire region where schools are located, especially within its North and Northeast regions, both historically more socio-economically disadvantaged. Projects exist, both broadly directed at Brazilian schools for the provision of connectivity through broadband, fibre, or satellite Internet connections, and directed at the North and Northeast, providing broader infrastructure for the community, and programmes dedicated to education. [4]

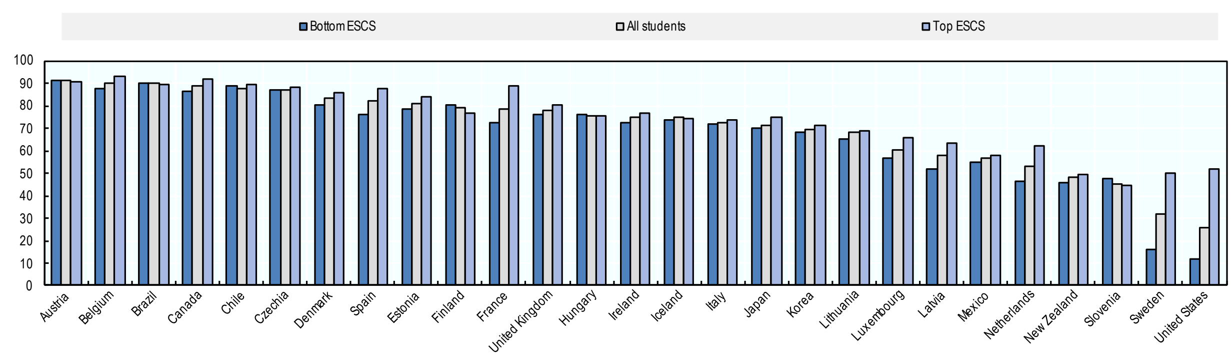
Similarly, access to the Internet is of central importance to Mexico, where access to high quality Internet and its provision by the government is a right enshrined on the Mexican constitution. [5] More specifically aimed at education, the provision of high-quality connectivity to schools is one of the axes of its 2020-2024 digital education agenda (*Agenda Nacional Educativa*), albeit no supporting initiative has been foreseen in the document.

However essential for connectivity, access is not sufficient: to assure adequate leveraging of digital education, a high-quality connection is critical. The next challenge after access, the provision of affordable quality connectivity, is still an open problem for several education systems in OECD Member countries, and not only in education. For instance, the provision of fibre connections, a piece of ICT infrastructure key for high-quality, high-speed Internet and the full transition to 5G still covers an unequal share of overall broadband connections even across high-income countries, with extremes such as Germany where less than 5% of all broadband connections are fibre-based (OECD, 2020[4]).

PISA 2018 data provide a pre-pandemic baseline for educational institutions: even across OECD countries, there is significant variation in the share of students enrolled at schools where Internet speed and/or bandwidth is considered sufficient (Figure 6.1).

Figure 6.1. Percentage of students enrolled at schools with sufficient Internet speed and/or bandwidth (2018)

As reported by principals through the PISA 2018 School Questionnaire



Note: Inferred through item SC155Q02HA, which asked schools whether "The school's Internet bandwidth or speed is sufficient", ordered by average ESCS.
Source: PISA 2018 database (OECD, 2019[5]).

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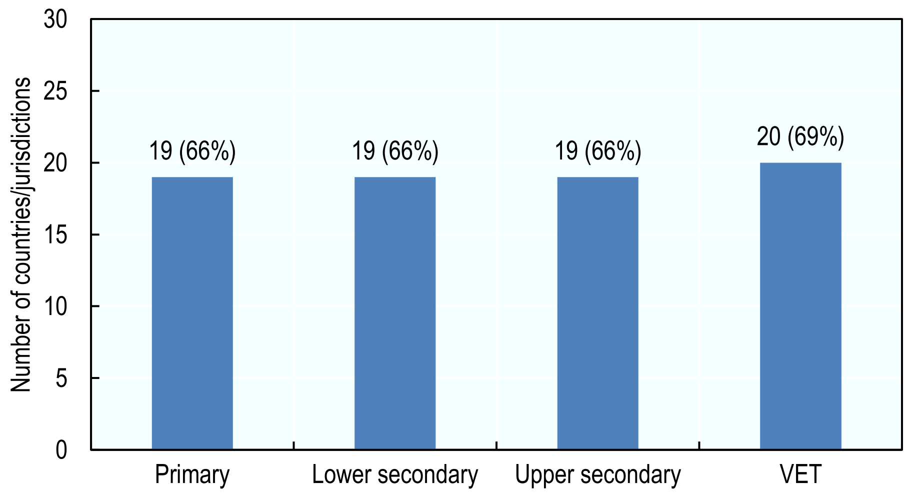
Figure 6.1 shows a lot of variation among the participating OECD Member countries regarding the share of students at schools with better Internet, but much less in the socio-economic gap indicating a difference in the quality of connections between schools serving socio-economically advantaged and disadvantaged students, Brazil and Mexico notwithstanding.

Indeed, amongst OECD Member countries, the share of students enrolled at schools with higher quality Internet ranged from 31.7% in Mexico to 91.2% in Lithuania, but with quite a variation along the way. In addition, several countries where significant shares of students with access to Internet-ready computers were enrolled at schools where this connection to the Internet is not deemed ideal by principals. For instance, virtually all 15-year-old students covered by PISA 2018 are in schools equipped with computers that can access the Internet, while only 45.2% of said students are in schools that reported a quality Internet connection.

These findings align with those found during the data collection with the 28 OECD Member countries and Brazil informing the present and other chapters. Regarding connectivity, countries were asked to look back in the previous five years and report on any change of policy regarding the provision of broadband Internet to schools, and to look forward to the next five years on whether the provision of access and high-quality Internet connections to institutions was envisioned as a policy goals.

Figure 6.2. Faster Internet as a policy focus in the past five years (2018-2022)



Note: More information can be found in Annex Table 6.A.1 at the end of this chapter.

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Figure 6.2 shows that the increase of Internet speed throughout all levels of the education system has been a policy focus for more than half participating countries over the past 5 years, with a small few responding on priorities related to particular levels (primary, secondary, or vocational education).[6] This aligns with the backdrop observed in 2018, where speeds were found lacking in schools for many participants.

Initiatives aimed at improving connectivity speed are underway in several participating countries. In Chile, dedicated connectivity programmes exist, some building on a decade-long legacy of bringing high-quality Internet connections to schools such as the "connectivity for education 2030" programme (*Conectividad para la Educación 2030*, CpE2030), that builds on a previous edition (the CpE2011) and aims to provide high-speed, quality Internet connections for schools throughout the country. A counterpart of the initiative exists for Easter Island (CpE-RapaNui), and a similar programme is in place for isolated rural or otherwise vulnerable areas (*Plan Última Milla*). [7]

Similar initiatives exist in Spain, where the "connected schools" initiative (*Escuelas Conectadas*) has focused on this since its first inception in 2015. Let by RED.es, a public company under the Spanish Ministry for Economic Affairs and Digital Transformation, and in tandem with other ministries, the initiative focused on the provision of high-speed Internet to schools. As of January 2023, the initiative reached all public schools in 12 out of 17 of Spain's autonomous regions and both autonomous cities of Ceuta and Melilla. [8]

While high-quality Internet connection in school is not achieved yet, and may remain a moving target, significant progress has been made in the past few years in the provision of mere connectivity. Across OECD countries, 91% of households report Internet access at home, albeit with significant differences between countries, ranging from almost 100% in Korea to 60% in Colombia (OECD, 2023[6]). Household coverage notwithstanding, high-quality connectivity at schools remains on the education policy agenda: most (22) education systems out of the 29 that participated in the OECD survey on digital educational infrastructure and governance have indicated that increasing access to the Internet at schools and providing fast Internet connections remains a policy priority for the next five years (Figure 6.3 and Figure 6.4), with a relatively small but noticeable focus on providing increasing connectivity at both lower and upper secondary education. [9] [10]

Figure 6.3. Internet access as policy priorities for the next five years (2024-2028)

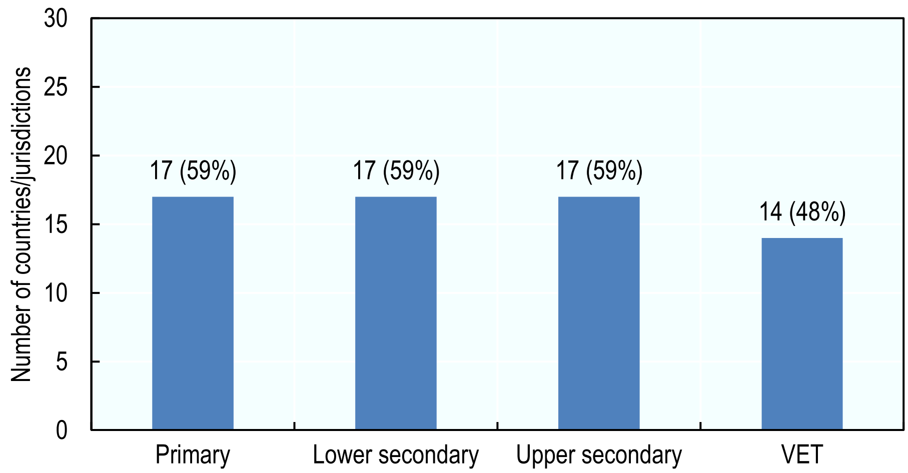

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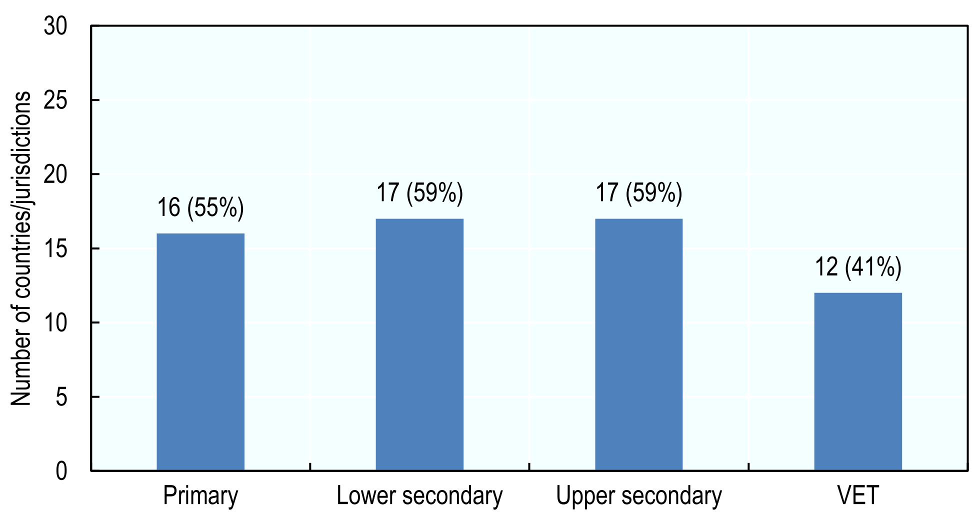
Figure 6.4. Internet speed as policy priorities for the next five years (2024-2028)



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Bridging this connectivity divide is an endeavour that will need a significant amount of resources, but ambitious initiatives are underway such as the one led in England (United Kingdom) by the Department for Education with the Department for Science, Innovation and Technology to invest up to GBP 82 million

(EUR 94.5 million) in a bid to upgrade Internet infrastructure to gigabit capable in all schools by the end of 2025, funding new infrastructure for all schools that are not likely to be covered by commercial Internet Service Providers and rely on an outdated physical ICT infrastructure.

Examples also exist on how coverage at the national level, with high-quality, reliable Internet connections is attainable, albeit facilitated by relatively smaller geographical spans. Notably in Estonia, all schools have high speed connectivity, with 75% able to rely on fibre connections. Standards for connection speeds are determined locally depending on the context, but all connections are able to provide speeds of at least one gigabit per second.

The last mile problem for connectivity in digital education

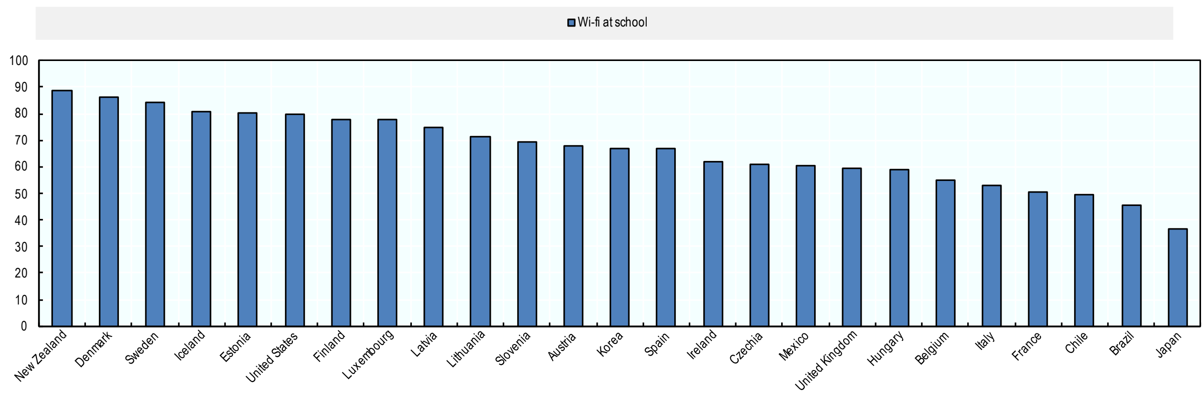
The “last mile problem” comes from the telecommunications industry, where, after building significant infrastructure, the capillarity problem of going the last mile and reaching customers at home emerged as a significant challenge. The same applies for the provision of connectivity, providing it at an infrastructure level, such as making high-quality Internet connections reach schools, or providing it in a limited fashion through restricted access in dedicated facilities (e.g., computer labs), are first but not definitive steps to fully leverage the potential of digital education. To fully reach students and teachers, connectivity must reach classrooms but also students and teachers at their homes or wherever they are, as made visible by unforeseen circumstances such as school closures due to a global public health emergency or displacements due to major geopolitical events.

This “last mile” of providing connectivity poses its own unique set of challenges due to the capillarity and inherent large scale of the problem. In order to make reliable connections to the Internet available in classrooms (mostly via wireless connections or Wi-Fi), schools need a high throughput Internet connection that supports an elevated number of simultaneous connections and large data flows, and equipment that handles these demands. This need creates a need for more specific support equipment, which in turn must be procured navigating a complex environment of technical configurations, then set up and maintained by specialised technical support staff.

The provision and procurement of equipment are discussed later in Chapter 12 (OECD, 2023[7]), while this section looks into the provision of last mile connectivity for and at schools, and to students themselves in the 28 OECD Member countries and jurisdictions plus Brazil that participated in the data collection exercise that informs this publication.

Similar to the availability of connectivity at school, data collected during PISA 2018 in OECD countries can provide an indication of the baseline provision of wireless connectivity for 15-year-old students in lower and upper secondary education. Countries and economies participating in PISA may opt for an additional component to the student questionnaire, asking students on the availability and use of Information and Communication Technology (ICT) resources. Incidentally, the ICT questionnaire also asks students whether wireless Internet is available at school, which provides a proxy and baseline of wireless availability at (lower and upper) secondary schools in 2018 (Figure 6.5).

Figure 6.5. Percentage of students with access to wireless Internet at school (2018)



Note: Canada and the Netherlands did not take the ICT questionnaire in PISA 2018 and were thus omitted from this Figure. Students were asked whether "Internet connection via wireless network" was available at school through item IC009Q06NA of the ICT questionnaire.
Source: PISA 2018 database (OECD, 2019[5]).

StatLink https://stat.link/mvrypz

Figure 6.5 indicates that there was quite a significant gap in the provision of wireless connectivity at school, with Wi-Fi being available to slightly over a third (36.8%) of Japanese students, and around half of Chilean and French students (49.7% and 50.6% of students respectively). However, there were already systems where wireless connectivity was already mostly available, such as Denmark (86.2%), and Sweden (84.1%). Albeit limited to secondary education, the PISA 2018 results paint a similar picture to that observed in European Union-wide contemporary surveys more broadly covering wireless connectivity at a systemic level ((European Commission, 2019[8])).

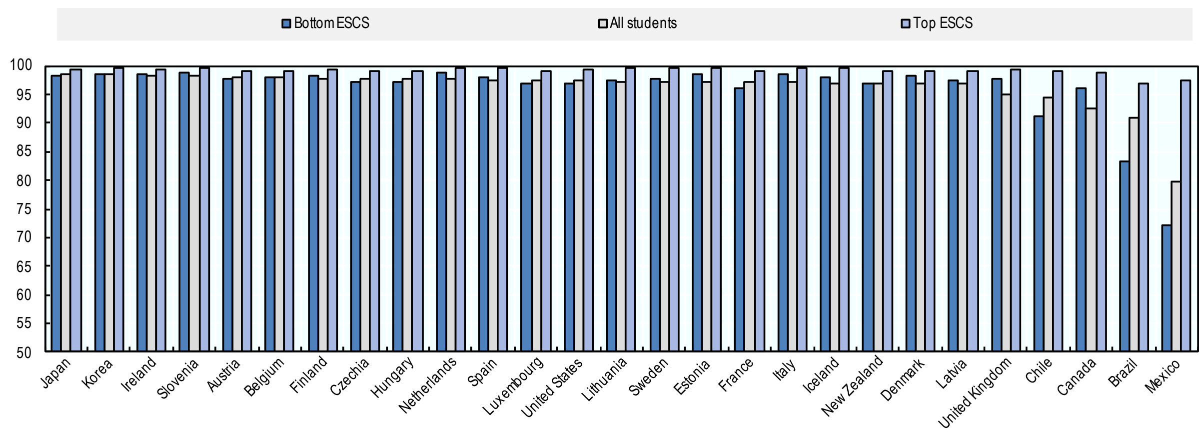
Responses from the participating countries to the *questionnaire on governance and public-private relations regarding education data and digital technology* circulated to governments, whose responses underlie the findings of this Chapter indicate that countries focused in bridging this gap in wireless connectivity in the following five years (Table 6.A.1) between 2018 and 2023. One of the lessons of the pandemic is indeed that even a small share of students with no or limited connectivity pose a problem when digital tools and resources are expected to be used for education, both in school and at home. (Vincent-Lancrin, 2022[9])

The Table shows that most participating countries focused on a systemic provision of wireless connectivity at schools, regardless of level (primary, secondary), or modality (general, vocational). Whether this focus produced effects on coverage at school level is yet to be seen in representative surveys, but several cases of national and sub-national programmes focusing on bringing wireless connectivity to schools can be highlighted.

One notable example is Japan. In 2018, Japan marked the smallest number of (secondary) students having access to wireless connections among OECD countries. Significant changes to digital education policy and expenditure were implemented to enhance, among other things, wireless and mobile connectivity at schools of all levels. This change led to marked increases in the adoption of Wi-Fi in Japanese schools: MEXT surveys document a sharp increase in adoption from 48.9% to 94.8% of schools between 2020 and 2022.

There is strong indication of the presence of connected smartphones in students' life in PISA 2018. Figure 6.6 shows that in most countries almost all students reported having at least one connected smartphone at home, even though it may not be their own device. Thinking about the access of digital resources through mobile phones is an important dimension of digital infrastructures.

Figure 6.6. Proportion of students with at least one connected smartphone at home (2018)



Note: Ordered by average ESCS for all students.
Source: PISA 2018 database (OECD, 2019[5]).

StatLink https://stat.link/68vm5y

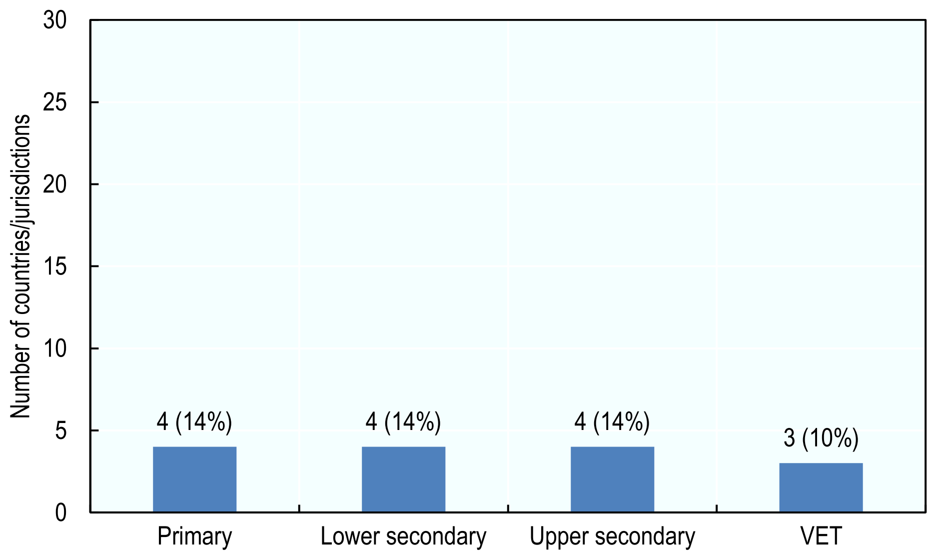
The proportion of students that reported the presence of Internet connected smartphones is rather elevated in all countries even within the less socio-economically advantaged households. Even where the smallest, albeit already elevated proportion was observed (Mexico, where 79.7% of students reported at least one connected smartphone at home), the proportion was still elevated for those in the bottom quartile for the socio-economic index (72.2%), indicating that students would feasibly be able to access public education platforms through smartphones if needed.

Some education systems such as Korea are looking beyond the provision of wireless connectivity for every student at school and focus on mobile connectivity. If not subsidised mobile connections themselves, Korea provided no data payment incurred when accessing public education platforms during the period of school closures caused by the COVID-19 pandemic in 2020, thus decreasing the barrier of access for these resources. Given the ubiquity of Internet-connected smartphones, this policy is bound to find significant traction and is currently being implemented by sub-national authorities, albeit with different data fee support policy depending on context.

Some initiatives along these lines were indeed pioneered during the global pandemic, such as the state of São Paulo in Brazil, where, besides the donation of devices should any be needed, the regional government provided support to families without mobile data packages, and brokered free access to educational platforms to diminish the cost of entry for families with limited mobile plans (Vincent-Lancrin, Cobo Romaní and Reimers, 2022[10]).

Besides the potential of these initiatives and some promise to the approach shown during the pandemic, only 5 out 29 countries that responded to the OECD survey on digital infrastructure and governance showed an overall interest in prioritising policy along these line in the next five years (Annex Table 6.A.2, Figure 6.7). [11]

Figure 6.7. Free mobile data for educational platforms as a policy priority in the next five years (2024-2028)



Note: N=29.

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Besides the sub-national Brazilian example above, other countries also put forth ambitious national-level support schemes to support continued learning during school closures due to COVID-19. Indeed, in the United Kingdom, the Department for Education supported efforts to bring connectivity to over 130 000 families through uplifts to their mobile data connections and the provision of 4G wireless routers to bring Internet to homes. This initiative included brokering agreements with the country's leading mobile service providers to also provide free data during the period to assure continued learning. Similar initiatives were also undertaken in Korea, where public-private partnerships were put in place during the period that included the provision of Internet-able devices with free data plans, as well as subsidies for Internet access subscriptions. Notably, these efforts were maintained in the aftermath of the pandemic but pivoted to promote educational innovation.

Equipment for schools and equity for students: digital device distribution policy

Connecting students, either at home or at school, with the best digital educational resources does not only require connectivity but also digital devices allowing students and teachers to engage with available resources and interact with digital learning platforms, a prerequisite to learning how to fully realise the potential of digital tools and resources.

The provision of devices, be at school or directly to students, is a complex and dynamic problem for education systems to address, given the ever-changing evolution of available technology, the complex landscape of technical specification and support infrastructure, the challenging assessment of needs and impact of costly distribution programmes in a context of relatively high existing device availability in most OECD countries.

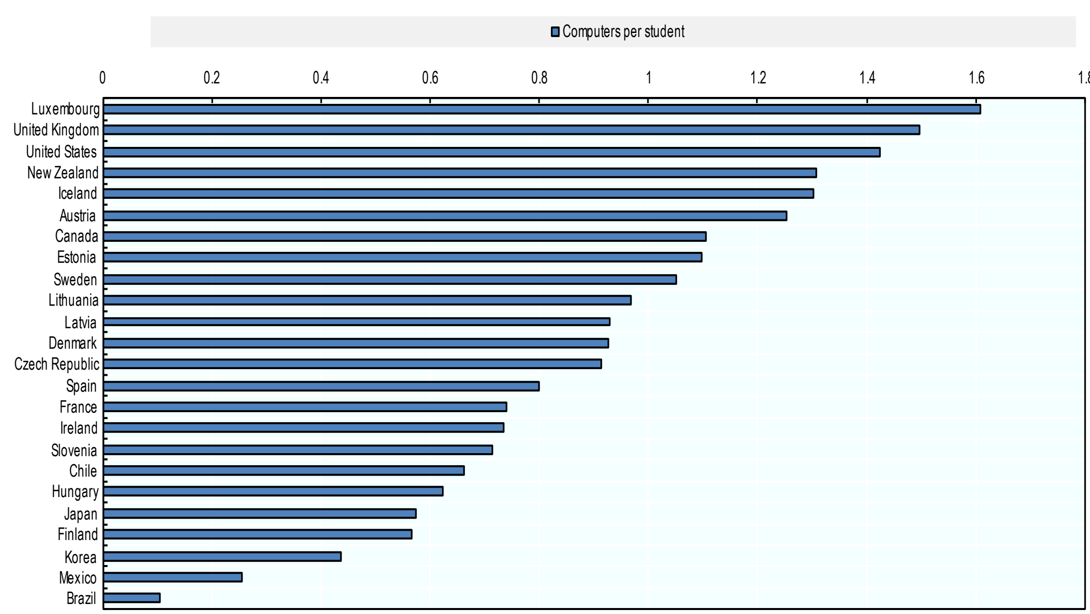
Even though well-equipped schools were associated with better learning outcomes in PISA 2018 (OECD, 2020), the evidence on pre-pandemic initiatives providing devices to students (e.g., "one laptop per child") showed little or no effect on learning outcomes (Cristia et al., 2017[11]). The drastic shift to distance learning caused by the COVID-19 pandemic changed the terms of this debate though: as school closures accumulated and lengthened, evidence gathered that students could not remotely continue their education due to a lack of connectivity or digital devices at home. The provision of digital devices appeared to not only to (often modestly) improve learning outcomes but as playing perhaps a more critical role as a driver of equity in education, providing students from all families with the conditions to continue their education with their peers (and effectively exercise their right to education).

This present section looks into these two aspects of digital device provision policy, as participants were invited to take stock of physical ICT hardware distribution policy in the past five years (2018-2022) and were invited to reflect on their distribution policy for the next five (2023-2028).

Equipping schools to fully benefit from digital tools and resources

Regarding computers available to students for educational purposes, at the system level, in 2018 there were on average 0.8 computers per student across the 37 OECD Member countries for which we have information, indicating a high level of availability overall (Figure 6.8).

Figure 6.8. Average computers per student, by participating country (2018)



Source: PISA 2018 database (OECD, 2019[5]).

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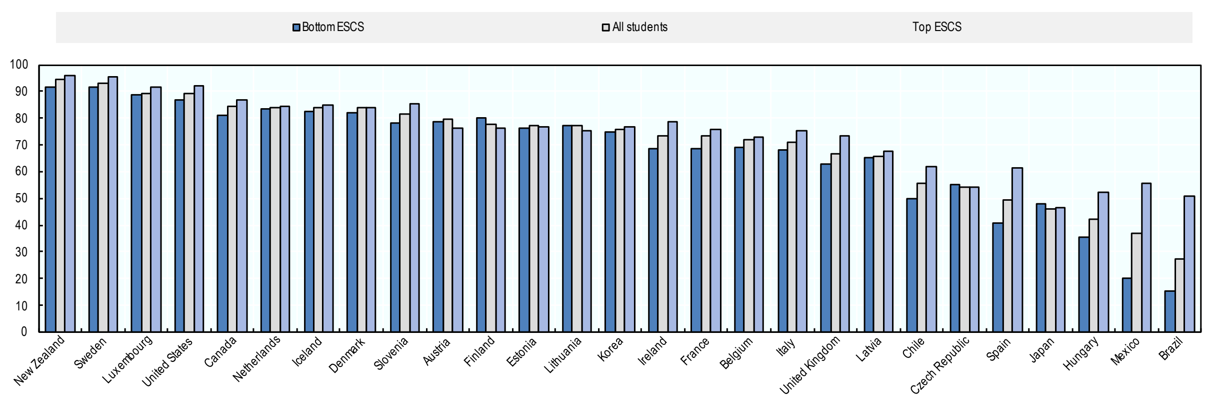
In 2018, there was thus a high overall but quite variable degree of provision, with nine countries (Austria, Canada, Estonia, Iceland, Luxembourg, New Zealand, Sweden, the United Kingdom, and the United States) averaging more than one computer per student, with others such as the Czechia, Denmark, Latvia and Lithuania relatively close of this benchmark, but others with quite a low number of computers available such as Korea (0.4), Mexico (0.2), and Brazil (0.1). The number of available computers for students might vary significantly not only between countries, but also within countries as well. Quality is also a significant dimension, and in 2018 schools serving students from different socio-economic backgrounds had marked differences in the power of the computer they worked with (Figure 6.9). The Figure shows the proportion of students enrolled at schools where principals consider that there is a sufficient number of devices for instruction and also indicates quite a lot of variability, some indicating a disagreement between the provision of computers and (perceived) quality, from 27.3% in Brazil, to 94.30% in New Zealand, but with interesting mismatches between the presence of computers and adequate specifications such as Latvia, where there was almost one (0.9 computer per student on average, but only 65% of students were enrolled in schools with computers deemed potent enough.

Figure 6.9. Percentage of students enrolled in schools where digital devices were considered computationally powerful enough (2018)



Note: Ordered by average ESCS, all students.
Source: PISA 2018 database (OECD, 2019[5])

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While the levels of availability have likely increased during the pandemic, there are likely still significant differences across and within countries in terms of the availability of devices, and of computer power depending on the socio-economic background of students.

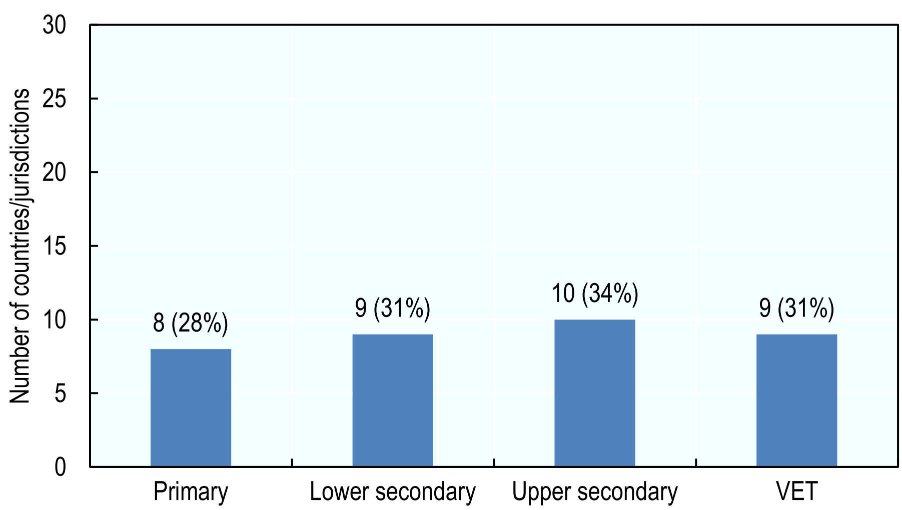
Driven by this reported a gap of provision but, also most likely by a need to update equipment at schools due to improvements in technology, countries have moved to prioritise the provision of digital devices to students. Indeed, in the past five years, most of participating countries have reported a change in policy or expenditures related to the provision of digital devices (Annex Table 6.A.1). Majority of (23) participating countries reported change in the past five years on policy or expenditure on the matter, with a few reporting more specific initiatives aimed at lower or upper secondary (2) or vocational education and training (1).

Economic and educational recovery plans in the aftermath of the COVID-19 pandemic also gave some momentum to equipment provision initiatives, with programmes aimed at the provision of digital devices to schools, often backed on significant planned expenditures and ambitious plans to further implement or accelerate digital transition. For instance, the *Digisprong* programme in the Flemish Community in Belgium is backed by a EUR 375 million bid to establish a future-oriented and secure ICT infrastructure, including plans to equip students from grade 5 onwards with devices on a one-to-one basis.

Beyond one-off initiatives for economic and education recovery, systemic and regular support for the provision, renewal, and maintenance might be particularly effective to support schools and to fully realise a given country's digital education strategy. One notable example of such policy is Ireland. As part of its efforts to implement its 2021-2027 Digital Strategy for Schools, Ireland puts in place a grant scheme for the provision of ICT infrastructure, underpinned by planned investments in excess of EUR 200 million, that schools can utilise to purchase and provide digital devices for students and teachers, among other uses.

Albeit with less focus on computers themselves but perhaps more on versatile devices such as laptops or tablets, the matter of provision is bound to remain relevant in education systems. When prompted to reflect on their priorities for the next five years, a smaller yet relevant number of participating countries reported a focus on the provision of laptops or tablets (Figure 6.10), with a slightly increased focus on later stages of the educational trajectory, such as upper secondary and vocational education and training. [12]

Figure 6.10. Priority on the provision of tablets and laptops for use at educational institutions, next five years (2024)



Note: N=29.

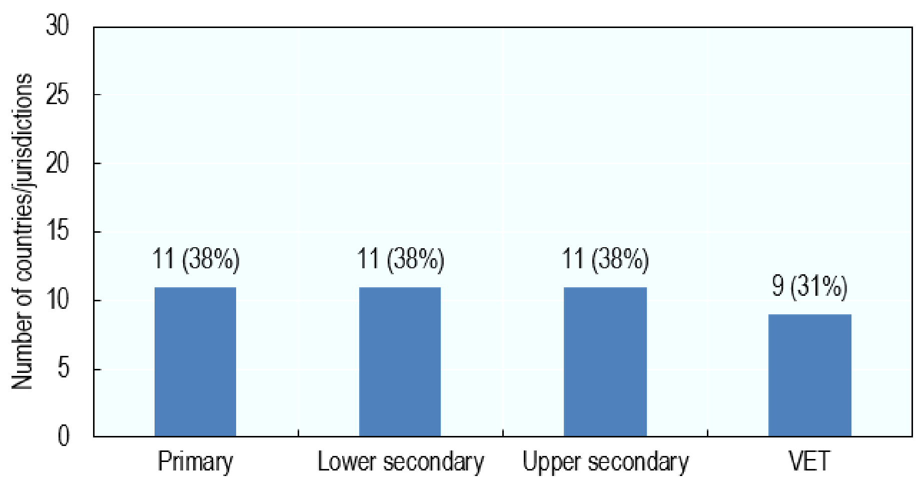
StatLink https://stat.link/yhueqx

Another alternative for students to have computers at their disposal at the classroom is for students to bring their own digital devices should they have one at their disposal. This approach is yet to be fully explored by education systems, and Canada is an example of this policy in place at the local level. Most schools in the country encourage bring-your-own-device (BYOD) policy in some way or another for learning purpose, with more or less directed guidance. Notably, in Prince Edward Island, there are directives allowing allow for the use of personal mobile devices in classrooms, within well-established expectations and limitations. While not as specific, other provinces such as Alberta, British Columbia, and Québec leave the use of personal mobile devices at the discretion of schools.

Personal-use devices, such as desktop computers, laptops, or tablets are not the only digital devices that can find their way into the classroom. Other devices such as interactive whiteboards, and simulation tools can also be used to support teaching and learning in the classroom. Support for the provision and use of these devices is on the radar for countries, some of which reported a focus on the provision of said devices in the next five years (Figure 6.11), with a slighter increased interest on the provision of these equipment for secondary education.[13]

One of the advantages of these devices is that they introduce computers in the classroom without changing its appearance; one of its disadvantages is that it may lead to the replication of practices that do not take advantage of the technology affordances (Avvisati, 2013[12]).

Figure 6.11. Priority on the provision interactive whiteboards and simulation tools (2024-2028)



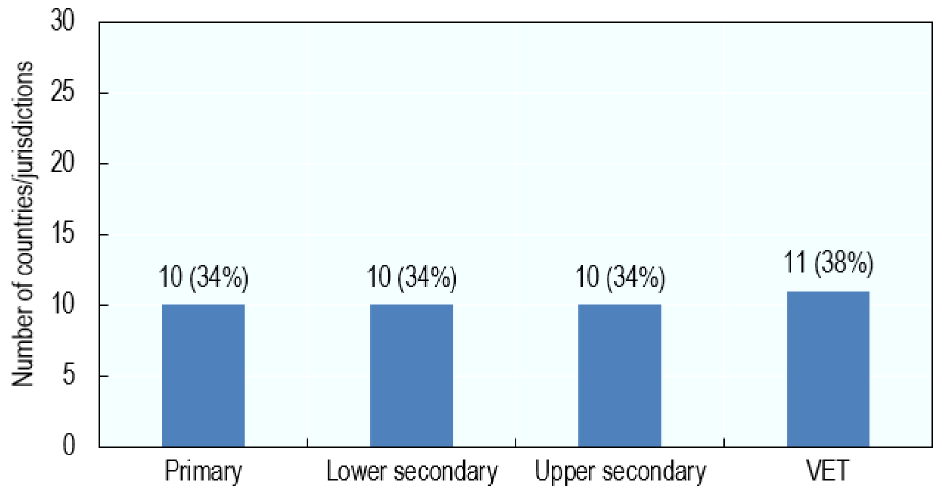
Note: N=29

StatLink https://stat.link/dt3bw8

Any kind of digital device used in the classroom also requires equipment to support of digital pedagogical activities: servers to support internal networks (Intranet), high-capacity routers to provide connectivity to networks, or even less specialised equipment such as printers. Although more distant from a given institution's educational mission, it is nonetheless equipment that must be procured, configured, and maintained, a responsibility requiring school and/or educational authorities' staff.

As such, an indicator of education systems' interest in improving their schools' Information Technology (IT) infrastructure lies in the provision/improvement of Intranet servers – a particularly specialised and technical piece of equipment (Figure 6.12). Among participating countries, nine reported a change in policy or expenditure for the provision of Intranet servers throughout all levels of education, indicating an interest on setting up the IT infrastructure of all schools[14].

Figure 6.12. Changes in policy/expenditure for Intranet servers in the past five years (2018-2022)



Note: More information can be found in Annex Table 6.A.1 at the end of this chapter. N=29.

StatLink https://stat.link/o5sbj7

The provision of this equipment is usually bundled with the provision of personal-use devices for students, and often the same pool of resources can be used for either the purchase of one devices or servers. For instance, the above-mentioned Irish ICT grant scheme allows for the purchase of devices for teachers and students, but also allows for the resources to be employed acquiring projectors, networking equipment (where servers and routers would be included), and other relevant equipment. Similarly, the Brazilian *Educação Conectada* programme, which can also provide a broad selection of equipment to schools, provides a comprehensive list of devices available to schools, from multimedia to fairly specialised IT equipment. This flexibility within earmarked IT funding programmes allows schools to modernise their equipment based on their local reality but also their pedagogical choices and preferences.

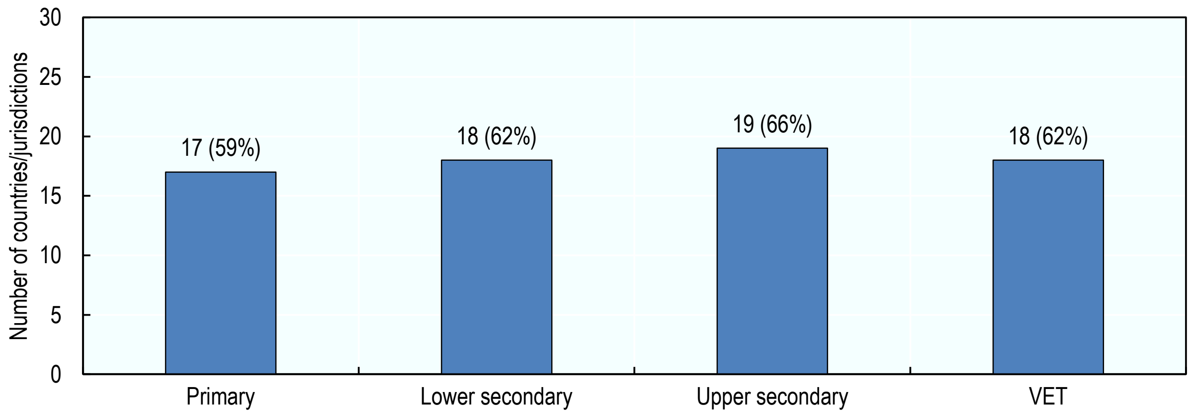
Supporting students' and teachers' access to digital education at home

As fundamental as equal access to sufficiently potent and up-to-date digital equipment is at school, the efficacy and reach of digital education policy might be limited by students' and teachers' access to digital technology at home, risking a gap in access and adoption due to disadvantaged socio-economic conditions, or lack of familiarity with digital devices. For example, albeit ubiquitous in daily life, access to a computer is not a guarantee worldwide, even across OECD member countries, where an average of 78% of households have access to a computer but with significant inequality across countries, from 97% of households in the Netherlands to 37% in Colombia (OECD, 2023[6]).

The abrupt shift to remote learning caused by COVID-19 put this divide in particular display, as some students found themselves unable to continue their education remotely due to a lack of digital equipment at home. As a response, many governments either set up or ramped up their digital device policies to use online learning as a way for education to continue for everyone, albeit remotely.

This move was reflected in recent changes in policy and expenditure to provide digital devices directly to students in most OECD countries and Brazil (Figure 6.13). Indeed, 20 out of the 29 responding governments reported a change in policy and/or expenditure related to the direct distribution of digital devices for students in the past five years, with marginal variations across educational levels.[15]

Figure 6.13. Change in policy and/or expenditure, providing devices for students in the past five years (2018-2022)



Note: More information can be found in Annex Table 6.A.1 at the end of this chapter. N=29.

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Several initiatives were proposed worldwide to provide access to education during the pandemic, some involving a high degree of domestic co-operation, either between sectors of government, or the establishment of public-private partnership to provide timely support for students.

For instance, in the Netherlands, the Ministry of Education, Culture, and Science cooperated with other ministries and agencies throughout the Dutch government in 2021 to revise its national 2019 Digitalization Agenda for Primary and Secondary Education into its Dutch Digitalisation Strategy 2021, leading to significant investments in providing devices to students for remote learning: around EUR 24 million were committed to provide 75 000 devices to students. Even more ambitious investment was made in Korea, where, in the wake of the global pandemic, the government set up public-private partnerships with device manufacturers and telecom providers, leading to the lease of 316 000 digital devices free of cost for disadvantaged students during the pandemic, with accompanying free mobile data plans during the pandemic.

A slightly different approach was adopted in New Zealand, where the Equitable Digital Access programme was scaled up to meet the needs created by the COVID-19 pandemic, but the provision of devices was not means-based, depending almost entirely on requests from schools for digital devices. Nonetheless, students enrolled in upper secondary education with socio-economic backgrounds measured within the bottom three deciles of the New Zealand socio-economic index were prioritised. This bottom-up approach, in which teachers in each school reported the needs of their students to principals, who in turn reported the aggregated need to the ministry led to the provision of over 49 000 digital devices to students, including to all year 9 to 13 students in need.

Looking forward, education systems, some still leveraging the moment created by post-pandemic education recovery programmes are still inclined to continue digital device distribution policies for students and teachers.

Conclusion: Seizing the momentum of post-pandemic recovery, knowing one's ICT infrastructure, and supporting its end users

Albeit extremely disruptive to education systems, the protracted period of school closures and unprecedented shift to remote or hybrid education caused by the COVID-19 pandemic prompted several initiatives in digital education in general, and in the provision of an enhanced physical digital infrastructure. Many countries invested in greater connectivity and providing their schools, teachers and/or students the digital devices that would be necessary to fully implement the goals of often wide-reaching digital education policy.

These pandemic-inspired policies also somehow shifted the debate around the direct provision of digital devices from a point of view related to the support of learning at school (an interest in the improvement of learning outcomes) to a perspective of equity and the willingness to support access to education and learning anywhere, whatever the socio-economic conditions of students.

As education systems take stock of the pandemic and return to a "new normal", the momentum and significant resources afforded by exceptional, pandemic-inspired initiatives, including budgets related to education recovery programmes, this shift might constitute a window of opportunity to provide better equipped and connected schools for students and teachers to return. Several education systems such as the Flemish community of Belgium, Ireland, France, New Zealand, and Korea, can provide examples of initiatives leveraging said resources and policy interest.

In addition, as education systems tackle the challenge of connecting and equipping schools, a related need for systematic and detailed information about countries' existing ICT infrastructure becomes more pressing. The OECD survey on digital infrastructure and governance showed that few countries performed systematic and frequent surveys of ICT infrastructure at school, such as those collected in the Brazilian school census (*Censo Escolar*) or by Japan's Ministry of Education (MEXT). International surveys, such as the European Union-wide *Survey of Schools – ICT in Education* (European Commission, 2019[8]), would allow accounting for the results of increased investment and initiatives of countries during and after the global pandemic in terms of hardware (and even software) available to schools, teachers and students.

Finally, connectivity and digital devices distribution initiatives cannot be "once and done" programmes, given the ever-changing needs created by the evolution of technology on the one hand, and by the life cycle of acquisition, maintenance, and replacement of digital devices on the other. However important, availability and provision are not sufficient for an efficient and sustainable implementation of digital education policy: often, Internet connectivity must be contracted and set up, digital devices acquired and configured, and once acquired, this infrastructure should be maintained and updated periodically.

Technical procurement for equipment and services and for ICT infrastructure maintenance are two tasks within the responsibilities of school staff in several education systems and thus an element of digital education policy. Procurement can be a powerful tool to shape the implementation of policy, and a more detailed discussion is presented in Chapter 12 (OECD, 2023[7]). Once goods and services have been acquired, the challenging of maintenance and support remains for education systems to tackle. Albeit this particular aspect has not been the objective of directed data collection on the scope of this Chapter, some particularly comprehensive support initiatives, such as those implemented by the Professional Development Service for Teachers (PDST) in Ireland (see the related publication (OECD, 2023[13])) provide an interesting implementation of support to schools that incorporates procurement, set-up, and technical support.

References

Avvisati, F. (2013), *Review of the Italian Strategy for Digital Schools*, OECD Publishing. [12]

Cristia, J.; P. Ibarrarán; S. Cueto; A. Santiago and E. Severín (2017), “Technology and child development: Evidence from the one laptop per child program”, *American Economic Journal: Applied Economics*, Vol. 9/3, pp. 295-320, https://doi.org/10.1257/app.20150385. [11]

European Commission (2019), *2nd Survey of Schools: ICT in Education*, https://digital-strategy.ec.europa.eu/en/library/2nd-survey-schools-ict-education-0. [8]

OECD (2023), *Country Digital Education Ecosystems and Governance: A Companion to Digital Education Outlook 2023*, OECD Publishing, Paris, https://doi.org/10.1787/906134d4-en. [13]

OECD (2023), *OECD Digital Education Outlook 2023: Towards an Effective Digital Education Ecosystem*, OECD Publishing, Paris, https://doi.org/10.1787/c74f03de-en. [7]

OECD (2023), *OECD Going Digital Toolkit*, https://goingdigital.oecd.org (accessed on September 2023). [6]

OECD (2020), *OECD Digital Economy Outlook 2020*, OECD Publishing, Paris, https://doi.org/10.1787/bb167041-en. [4]

OECD (2019), *PISA 2018 Database*, https://www.oecd.org/pisa/data/2018database/ (accessed on 25 June 2023). [5]

OECD (2019), *PISA 2018 Results (Volume I): What Students Know and Can Do*, PISA, OECD Publishing, Paris, https://doi.org/10.1787/5f07c754-en. [3]

OECD (2016), *OECD Ministerial Declaration on the Digital Economy: Innovation, Growth and Social Prosperity (“Cancún Declaration”)*, https://www.oecd.org/internet/Digital-Economy-Ministerial-Declaration-2016.pdf. [2]

OECD (2004), *Recommendation of the Council on Broadband Connectivity*, https://legalinstruments.oecd.org/en/instruments/OECD-LEGAL-0322. [1]

Vincent-Lancrin, S. (2022), *How Learning Continued during the COVID-19 Pandemic: Global Lessons from Initiatives to Support Learners and Teachers*, OECD Publishing, Paris, https://doi.org/10.1787/bbeca162-en. [9]

Vincent-Lancrin, S., C. Cobo Romaní and F. Reimers (eds.) (2022), *How Learning Continued during the COVID-19 Pandemic: Global Lessons from Initiatives to Support Learners and Teachers*, OECD Publishing, Paris, https://doi.org/10.1787/bbeca162-en. [10]

Annex 6.A. Participating countries' responses to the digital infrastructure and governance instruments

This Annex presents a breakdown of participating countries' responses on their past and future priorities with regards to connectivity and hardware policy to the data collection instruments circulated by the OECD, the *Questionnaire on digital education infrastructure* and the *Questionnaire on governance and public-private relations regarding education data and digital technology*.

Annex Table 6.A.1. In the past five years, did your government make any significant changes to its digital education policy and/or expenditures for any of the following? (2024)

	Broadband connection in schools	Wi-Fi or mobile connections (in schools)	Devices in schools	Devices for students	Devices for students with special needs	Intranet servers in schools	Other
Austria	✓	✓	✓	✓	✓		
Brazil	✓	✓	✓	✓	✓	✓	✓
Canada	✓		✓	✓	✓		
Chile	✓	✓	✓	✓	✓	✓	
Czechia	✓		✓	✓	✓		
Denmark							
Estonia		✓	✓			✓	
Finland	✓	✓	✓	✓	✓		
France	✓	✓	✓	✓	✓	✓	
Hungary	✓	✓	✓	✓			✓
Iceland							
Ireland							
Italy	✓	✓	✓	✓	✓	✓	
Japan		✓	✓	✓	✓		
Korea	✓	✓	✓	✓			
Latvia	✓	✓	✓	✓	✓		
Lithuania		✓	✓		✓		
Luxembourg	✓	✓	✓	✓	✓	✓	✓
Mexico							
Netherlands	✓	✓					
New Zealand	✓	✓	✓	✓	✓		✓
Slovenia	✓	✓	✓	✓	✓	✓	
Spain	✓	✓	✓	✓	✓	✓	
Sweden							✓
Türkiye	✓	✓	✓		✓		✓
United States	✓	✓	✓	✓	✓	✓	✓
England (United Kingdom)	✓	✓	✓	✓	✓		
Flemish Comm. (Belgium)	✓	✓	✓	✓	✓		✓
French Comm. (Belgium)	✓		✓	✓	✓		
Total (29)	**21**	**21**	**23**	**20**	**20**	**9**	**8**

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Annex Table 6.A.2. In terms of hardware infrastructure (equipment, connectivity, etc.), what are the main priorities of your level of government in the next five years? (2024)

	Devices for students in schools	Devices for students in schools and at home	Devices for teachers	Specific digital teaching equipment (e.g. interactive whiteboards, simulation tools)	Internet access in schools	Internet access everywhere (e.g. satellite Internet)	Internet speed in schools	Internet speed at home	Free mobile data roaming to access public education platforms	Other priorities
Austria		✓	✓		✓		✓			
Brazil	✓		✓	✓	✓		✓		✓	
Canada					✓	✓	✓			
Chile	✓				✓		✓			
Czechia	✓			✓	✓					
Denmark										
Estonia	✓		✓	✓	✓		✓			
Finland		✓	✓							
France										
Hungary		✓	✓	✓	✓		✓			
Iceland										
Ireland		✓	✓	✓	✓		✓	✓		
Italy										
Japan		✓								
Korea	✓*	✓*	✓*		✓*		✓*			
Latvia		✓	✓		✓	✓	✓			
Lithuania	✓	✓	✓	✓	✓		✓			
Luxembourg										
Mexico						✓	✓		✓	
Netherlands										
New Zealand			✓		✓	✓	✓	✓	✓	

	Devices for students in schools	Devices for students in schools and at home	Devices for teachers	Specific digital teaching equipment (e.g. interactive whiteboards, simulation tools)	Internet access in schools	Internet access everywhere (e.g. satellite Internet)	Internet speed in schools	Internet speed at home	Free mobile data roaming to access public education platforms	Other priorities
Slovenia	✓	✓	✓	✓	✓		✓	✓	✓	✓
Spain	✓	✓*		✓	✓		✓	✓	✓*	
Sweden										
Türkiye				✓	✓					
United States					✓	✓				
England (United Kingdom)					✓		✓			
Flemish comm. (Belgium)	✓		✓	✓	✓		✓			
French comm. (Belgium)	✓	✓	✓	✓	✓		✓			
Total (29)	**13**	**12**	**15**	**13**	**22**	**5**	**19**	**5**	**5**	**1**

Note: A star (*) indicates that this provision is a priority at subnational levels of government, e.g. states, regions, municipalities.

StatLink https://stat.link/e82flz

Notes

[1] This lower bound was chosen using the average class size for lower secondary education indicator from the 2018 edition of *Education at a Glance*, (OECD, 2022) retrieved from the 2022 database (https://www.oecd-ilibrary.org/education/data/oecd-education-statistics/education-at-a-glance-student-teacher-ratio-and-average-class-size-edition-2022_affd2303-en, accessed September 2023).

[2] The Economic, Social, and Cultural Status (ESCS) is an internationally comparable and longitudinal measure of socio-economic status used in PISA that combines parental education, occupation, and home possessions as predictors. More detail can be found in the PISA 2018 Technical Report (OECD, 2019).

[3] Axis D of the Brazilian strategy for digital transformation (*Eixo D: Educação e Capacitação Profissional, Estratégia Brasileira para a Transformação Digital*, https://www.gov.br/mcti/pt-br/acompanhe-o-mcti/transformacaodigital/estrategia-digital-eixoD, accessed in August 2023) and Article 2 – IV of Law 14 533 from 11 January 2023 (*Politica Nacional de Educação Digital*, https://www.planalto.gov.br/ccivil_03/_Ato2023-2026/2023/Lei/L14533.htm, accessed in August 2023).

[4] Namely, the connected education programme (*Programa Nacional Educação Conectada*, link, accessed in August 2023) provides support for schools to access the Internet, with the connected North and Northeast programmes (Norte Conectado, https://www.gov.br/mcom/pt-br/acesso-a-informacao/acoes-e-programas/programas-projetos-acoes-obras-e-atividades/norte-conectado, and Nordeste Conectado https://www.gov.br/mcom/pt-br/acesso-a-informacao/acoes-e-programas/programas-projetos-acoes-obras-e-atividades/nordeste-conectado, respectively) focusing on infrastructure and supported by the Aprende Mais Norte e Nordeste project supported by the World Bank (https://www.gov.br/mec/pt-br/acesso-a-informacao/institucional/estrutura-organizacional/orgaos-especificos-singulares/secretaria-de-educacao-basica/programas-e-acoes/educa-mais-norte-e-nordeste).

[5] Article 6 of the Mexican Constitution (*Artículo 6o, Constitución Política de los Estados Unidos Mexicanos*, link, accessed in August 2023), and Digital Education Agenda (*Agenda Nacional Educativa*, https://infosen.senado.gob.mx/sgsp/gaceta/64/2/2020-02-05-1/assets/documentos/Agenda_Digital_Educacion.pdf, accessed in August 2023).

[6] Participant responses for Figure 6.2: All levels (21): Austria, Belgium (French and Flemish communities), Brazil, Canada, Chile, Estonia, Finland, France, Hungary, Italy, Korea, Latvia, Luxembourg, New Zealand, Slovenia, Spain, the Netherlands, and the United States. Primary (1): Ireland. Lower Secondary (2): Brazil* and Ireland. Upper Secondary (2): Brazil* and Japan. VET (2): Brazil* and Korea. The asterisk indicates that only sub-national (regions/municipalities) support is present.

[7]https://www.innovacion.mineduc.cl/iniciativas/transformaci%C3%B3n-digital/conectividad, last accessed August 2023.

[8]https://www.red.es/es/iniciativas/escuelas-conectadas, last accessed September 2023.

[9] Participant responses for Figure 6.3: Primary education (17): Belgium (French and Flemish communities), Brazil, Canada, Estonia*, Finland, Iceland, Italy, Korea*, Latvia, Luxembourg, Slovenia, Spain, Sweden, the United Kingdom, the United States and Türkiye. Lower Secondary (17): Belgium (French and Flemish communities), Brazil, Canada, Estonia*, Finland, Iceland, Italy, Korea*, Latvia, Luxembourg, Slovenia,

Spain, Sweden, the United Kingdom, the United States and Türkiye. Upper Secondary (17); Belgium (French and Flemish communities), Brazil, Canada, Estonia*, Finland, Iceland, Italy, Korea*, Latvia, Luxembourg, Slovenia, Spain, Sweden, the United Kingdom, the United States and Türkiye. VET (14): Belgium (French and Flemish communities), Brazil, Canada, Estonia*, Finland, Korea*, Latvia, Luxembourg, Spain, Sweden, the United Kingdom, the United States and Türkiye. The asterisk indicates that only sub-national support was reported.

[10] Participant responses for Figure 6.4: Primary education (16): Austria, Belgium (French and Flemish communities), Brazil, Canada, Chile, Estonia, Hungary, Ireland, Korea*, Lithuania, Mexico, New Zealand, Slovenia, Spain, and the United Kingdom; Lower secondary (17): Austria, Belgium (French and Flemish communities), Brazil, Canada, Chile, Estonia, Hungary, Ireland, Korea*, Latvia, Lithuania, Mexico, New Zealand, Slovenia, Spain, and the United Kingdom; Upper secondary (17): Austria, Belgium (French and Flemish communities), Brazil, Canada, Chile, Estonia, Hungary, Ireland, Korea*, Latvia, Lithuania, Mexico, New Zealand, Slovenia, Spain, and the United Kingdom; VET (12): Austria, Belgium (French and Flemish communities), Brazil, Canada, Chile, Estonia, Korea*, Lithuania, Slovenia, Spain, and the United Kingdom. The asterisk indicates only sub-national support was reported.

[11] Participant responses for Figure 6.7: Primary (4): Mexico, New Zealand, Slovenia, and Spain*; Lower secondary (4): Mexico, New Zealand, Slovenia, and Spain; Upper secondary (4): Mexico, New Zealand, Slovenia, and Spain*; VET (3): Brazil, Slovenia, and Spain*. The asterisk indicates that only sub-national support was reported.

[12] Participant responses for Figure 6.10: Primary (8); Belgium (French and Flemish communities), Czechia, Estonia*, Korea*, Lithuania, Slovenia, and Spain; Lower secondary (9): Belgium (French and Flemish communities), Brazil*, Czechia, Estonia*, Korea*, Lithuania, Slovenia, and Spain; Upper secondary (10): Belgium (French and Flemish communities), Brazil*, Czechia, Estonia*, Korea*, Lithuania, Slovenia, and Spain; VET (9): Belgium (French and Flemish communities), Brazil*, Czechia, Chile, Estonia*, Korea*, Lithuania, Slovenia, and Spain. The asterisk indicates that only sub-national support was reported.

[13] Participant responses for Figure 6.11: Primary (11): Belgium (French and Flemish communities), Brazil, Czechia, Estonia*, Hungary, Ireland, Lithuania, Slovenia, Spain, and Türkiye; Lower secondary (11): Belgium (French and Flemish communities), Brazil, Czechia, Estonia*, Hungary, Ireland, Lithuania, Slovenia, Spain, and Türkiye; Upper secondary (11): Belgium (French and Flemish communities), Brazil, Czechia, Estonia, Hungary, Ireland, Lithuania, Slovenia, Spain, and Türkiye; VET (9): Primary (11): Belgium (French and Flemish communities), Brazil, Czechia, Estonia, Hungary, Ireland, Lithuania, Slovenia, Spain, and Türkiye. The asterisk indicates that only sub-national support was reported.

[14] Participant responses for Figure 6.12: All levels (10): Brazil, Chile, Estonia, France, Italy, Korea*, Slovenia, Spain, and the United States; Lower secondary (1): Brazil*; Upper Secondary (1): Brazil*, VET (2): Brazil* and Latvia. The asterisk indicates that only sub-national support was reported.

[15] Participant responses for Figure 6.13: All levels (17): Austria, Belgium (French community), Brazil, Canada, Chile, Finland, France, Italy, Japan, Korea, Latvia, Luxembourg, New Zealand, Slovenia, Spain, the United Kingdom and the United States; Lower secondary (2): Brazil* and Hungary; Upper Secondary (3): Belgium (Flemish community), Brazil*, and Hungary; VET (2): Belgium (Flemish community) and Brazil*. The asterisk indicates only sub-national support was reported.

7 Teacher digital competences: formal approaches to their development

Natalie Foster, OECD

This chapter outlines teacher digital competences and examines different approaches to formalising their development across OECD countries. Three main approaches are discussed: 1) setting standards for both teachers and students on digital competences; 2) incentivising continuous professional development on digital competences for educators; and 3) developing a wider ecosystem of support for stakeholders on digital education matters. The chapter presents case studies across countries to illustrate the possible policy levers that can be implemented within each approach, including formal certification and examination processes, linking standards to teacher education accreditation, new career development pathways and forms of skills recognition, flexible and accessible training opportunities, dedicated support organisations, and wider innovation or school digitalisation initiatives.

Introduction

While available hardware and software are critical components of a digital education infrastructure, so are the human resources that operate within that infrastructure: namely teachers and school principals. Teachers are vital "change agents" in school digitalisation processes and digital technologies have the potential to change the nature of their work. For example, learning analytics tools can inform teaching decisions, school curricula are evolving to recognise the importance of developing students' digital skills, new online communication tools enable interaction with parents and professional collaboration with other teachers, and open educational resources are democratising the availability of digital learning resources on diverse topic areas (Yu, Vidal and Vincent-Lancrin, 2023[1]). Although governments, local municipalities and school leaders can provide and even mandate the use of such tools and applications to teachers, there is no guarantee that they will be used to enhance teaching and learning unless teachers feel empowered and motivated to do so.

The content of teachers' formal education and training is important for teaching quality and practice. Data from the latest OECD Teaching and Learning International Study (TALIS) conducted in 2018 showed that lower secondary teachers in OECD countries reported lower levels of self-efficacy in teaching using Information and Communications Technology (ICT) compared to other classroom management, instruction and student engagement practices (OECD, 2019[2]). Data also showed that, on average across OECD countries, around 1 in 5 secondary education teachers report the need for further training in this area despite 60% of teachers having participated in professional development on digital education in the past 12 months and despite a general increase in teacher participation in professional development in this area since 2013 (OECD, 2019[2]).

The need for formal training and professional development on teaching using ICT will remain important given the ubiquity of digital technologies and given the proliferation of national digitalisation strategies, including supporting the development of citizens' digital skills (OECD, 2022[3]). However, digital technologies in education systems are not in themselves a transformative force: they require educators who know how to use them in ways that can strengthen innovative teaching practices and improve learning outcomes. OECD data from the Programme for International Student Assessment (PISA) show that simply exposure to digital technologies in education is not associated with improved student learning, highlighting the importance of the mediation and training of teachers (OECD, 2015[4]). Teachers must therefore develop appropriate competences and attitudes towards using digital technologies and integrating them successfully in teaching practices.

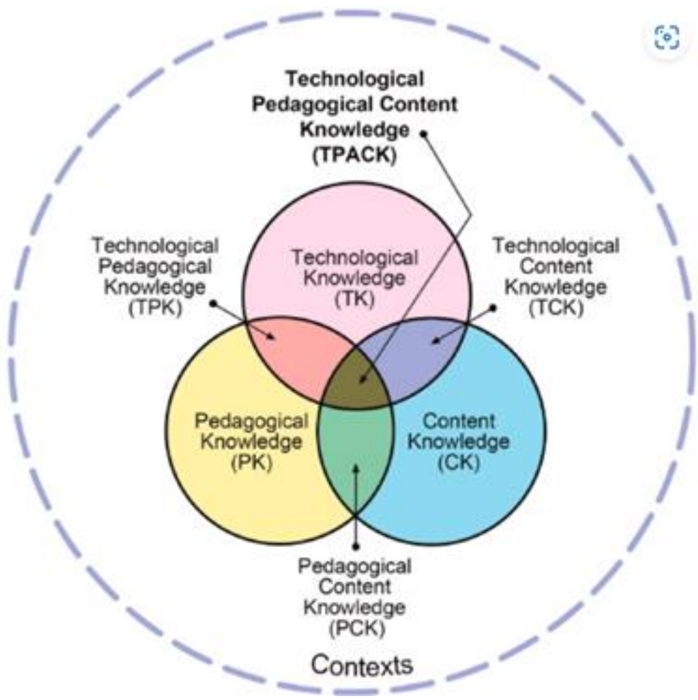
Governments can formalise the development of teacher digital competences in several ways, and investing in doing so is a key area of many countries' digital education policies. This chapter first provides a brief overview of teacher digital competences before examining different approaches and policy levers to fostering their development. Approaches include setting and enforcing standards on digital competences for teachers and students, incentivising teacher professional development on digital education, and creating a wider ecosystem of support for digital education matters for stakeholders.

Teacher digital competences: what are they?

Digital technologies now extend into all areas of a teacher's work including teaching and learning, assessment, communicating and collaborating with colleagues and parents, and creating and sharing digital content and resources. Teachers thus need to develop both general digital skills (as everyday users of digital technologies) and teaching-specific digital competences that can support them as educators and professionals in digital environments. Several international frameworks describe the different components of teachers' digital competences with the aim of assisting national governments to embed relevant digital competences into teacher education (Redecker, 2017[5]; UNESCO, 2018[6]; ISTE, 2017[7]).

One influential framework focusing on the integration of technology in teaching is the Technological Pedagogical Content Knowledge (TPACK) framework that identifies three core teacher knowledge domains: 1) understanding how to select and use technology to facilitate student learning ("technological knowledge"); 2) pedagogical decision-making and understanding ("pedagogical knowledge"); and 3) specific content knowledge for a given subject or topic area ("content knowledge") (Mishra and Koehler, 2006[8]; Koehler, Mishra and Cain, 2013[9]). These core knowledge areas are typically represented in a Venn diagram to emphasise how the overlapping of the three areas results in key combinations of knowledge and skills (Figure 7.1). For example, Technological Pedagogical Knowledge (TPK) refers to "knowledge of the existence, components, and capabilities of various technologies as they are used in educational settings, and conversely, knowing how teaching might change as the result of using particular technologies" (Mishra and Koehler, 2006, p. 1028[8]).

Figure 7.1. The Technological Pedagogical Content Knowledge (TPACK) framework



Source: © 2012 by tpack.org, reproduced by permission of the authors (Koehler and Mishra).

The TPACK framework emphasises that the successful integration of technology in teaching uses all three types of knowledge simultaneously, thus requiring teachers to develop complex forms of teacher knowledge. The authors contrast their framework with other approaches that tend to be technocentric, arguing that others overly focus on teachers' general technology skills while ignoring the complex relationship between technology, content, pedagogy and context (Harris, Mishra and Koehler, 2009[10]).

A recent review of research exploring primary and general secondary teacher preparation for the digital age found that teacher digital competences tend to be framed in three ways: 1) generic digital competence; 2) digital teaching competence; and 3) professional digital competence (Starkey, 2020[11]). Each of these competences are briefly described below. One additional digital competence area relates to technology-specific skills like programming, computational thinking, or graphic design for the purpose of teaching certain subject areas. While the need for capable and skilled teachers in those subject areas is increasing, as reflected in recent changes in student curricula across the world, for the purposes of this chapter we refer primarily to the digital competences required of all general subject teachers when using the umbrella term “teacher digital competences”.

Generic digital competence

Generic digital competence refers to digital skills that are not specific to teaching or the professional work of a teacher. This body of knowledge is synonymous with the “technological knowledge” component of the TPACK framework and refers to the ability to use hardware and carry out common computer-based practices like using email, searching the Internet, troubleshooting, using standard word-processing and presentation software, and using creative and collaborative technologies (Starkey, 2020[11]). Essentially, generic digital competence is framed as the body of generic knowledge and skills relevant to anyone using a computer for working or learning. OECD data from the Survey of Adult Skills (PIAAC) showed that the share of teachers with low general problem-solving skills in technology-rich environments ranged significantly across OECD countries with available data, from less than 5% of teachers in Australia to 31% of teachers in Israel (OECD, 2019[12]).

Digital teaching competence

Digital teaching competence refers to the ability to integrate digital technology into teaching practices, sometimes also referred to as “digital pedagogies” or “digitally supported teaching methods”, and is most closely aligned to the “technological pedagogical knowledge” area of the TPACK framework. Integrating digital tools into pedagogical practice includes the use of various media, communication and computational tools for teaching and learning activities, developing and using digital assessments, appropriately managing digital environments, and supporting students’ critical, ethical and creative use of ICT for learning (Starkey, 2020[11]). The integration of ICT in teaching practices requires teachers to be able to use technologies in their function as a teacher, critically selecting technologies for specific teaching purposes and facilitating students to learn through and with digital tools to achieve defined learning outcomes.

Professional digital competence

Professional digital competence is an emerging and broader type of teacher digital competence that is inclusive of all aspects of being a teacher in schooling contexts and education systems where digital technologies are embedded (Starkey, 2020[11]). For example, teachers now commonly use learning management systems to manage and coordinate student learning, which involves aspects that mirror the physical space (e.g. managing student interactions, online resources, student motivation and assessment) as well as those that are unique to the digital space (e.g. managing learning and communication with students beyond the confines of school walls) that must be negotiated within a wider school context. The professional work of being a teacher in increasingly digitised education systems also now includes participating in online communities of learning, engaging in formal and informal professional learning, and communicating with parents and the broader the school community (Tondeur et al., 2017[13]), as well as using data (e.g. analytics about students available via information and learning management systems) to inform their teaching.

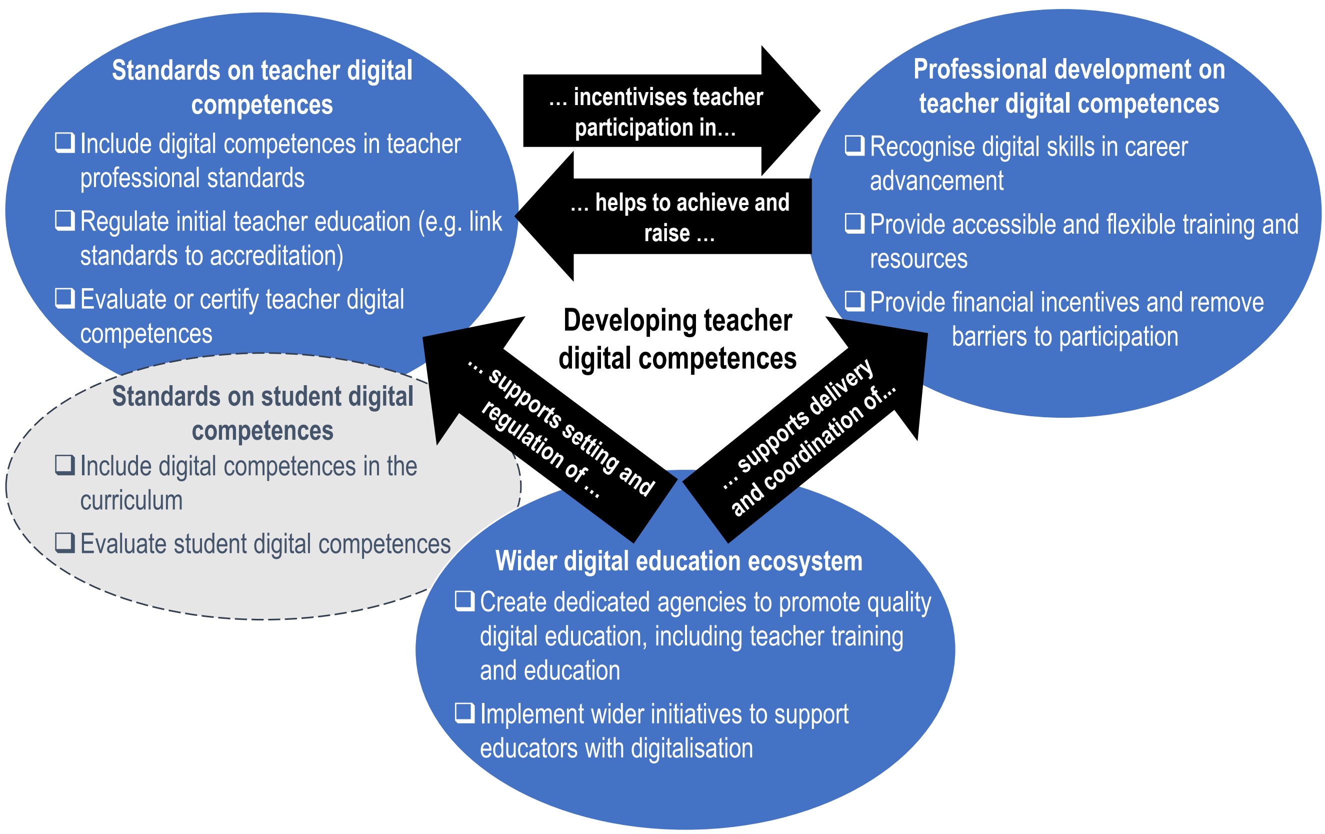
Approaches to formalising the development of teacher digital competences

To foster, incentivise and support the development of teacher digital competences – understood as the competences that allow teachers to work as modern professionals and as pedagogues – education systems can adopt different approaches and associated policy levers (Figure 7.2). These include:

- Setting teacher professional standards on digital competences (in collaboration with other relevant stakeholders, such as teacher unions or teacher training programmes) and proactively enforcing standards through teacher certification or evaluation processes, or teacher education provider accreditation processes;

- Setting standards on the acquisition of student digital competences and monitoring related learning outcomes through student assessment and evaluation;
- Providing incentives for teachers to participate in relevant professional development activities by recognising digital skills development in career progression, ensuring access to flexible training opportunities, providing financial incentives, and removing traditional barriers to participation; and
- Creating a wider digital education ecosystem to coordinate school digitalisation initiatives and innovation projects, and support stakeholders to develop teacher digital competences.

Figure 7.2. Approaches and policy levers to formalise the development of teacher digital competences



Setting and regulating teacher standards

Of the 29 OECD countries and jurisdictions that participated in our comparative study, 24 reported that they have national (or central) rules or guidelines on developing teacher digital competences in the context of pre-service or in-service training (or both) (Table 7.1 and Figure 7.3). Rules and guidelines include teacher professional standards, teacher competence frameworks, or other laws or directives governing the teaching profession. Only 5 among the respondent countries and jurisdictions do not have any national rules or guidelines on developing teacher digital competences, although in some cases these may exist at lower levels of government (e.g. central state or regional rules, or just local).

Table 7.1. Rules and guidelines on developing teacher digital competences

Country/jurisdiction	Pre-service teacher training			In-service teacher training		
	Rules (and guidelines)	Guidelines only	Fully devolved to subgovernments	Rules (and guidelines)	Guidelines only	Fully devolved to subgovernments
Austria		✓			✓	
Brazil		✓[1]			✓[1]	
Canada			✓			✓
Chile	✓			✓		
Czechia		✓				✓
Denmark	✓					
Estonia	✓				✓	
Finland						✓
France		✓			✓	
Hungary	✓*					
Iceland						✓
Ireland	✓*				✓	
Italy	✓			✓*		
Japan	✓					
Korea	✓[1]				✓[1]	
Latvia	✓				✓[1]	
Lithuania		✓			✓	
Luxembourg	✓					
Mexico						
Netherlands		✓			✓	
New Zealand	✓				✓	
Slovenia		✓			✓*	
Spain	✓				✓[1]	
Sweden	✓					✓
Türkiye						
United States		✓[1]			✓[1]	
England (United Kingdom)	✓*					✓
Flemish Comm. (Belgium)				✓		
French Comm. (Belgium)	✓				✓	
Total (29)	**15**	**8**	**1**	**3**	**14**	**6**

Note: ✓ denotes rules or guidelines at all educational levels. ✓* denotes rules or guidelines at all educational levels excluding VET (i.e. primary, lower secondary and upper secondary education). ✓[1] denotes educations systems in which lower levels of government also share responsibility to define further rules and guidelines on teacher digital competences, which they may or may not do. All "✓" in the "fully devolved" column denote education systems in which lower levels of government (i.e. state, regional or municipal) have the exclusive responsibility to define rules and guidelines on teacher digital competences; note, however, that it does not signal that the relevant governing authorities within those systems necessarily do define such rules or guidelines.

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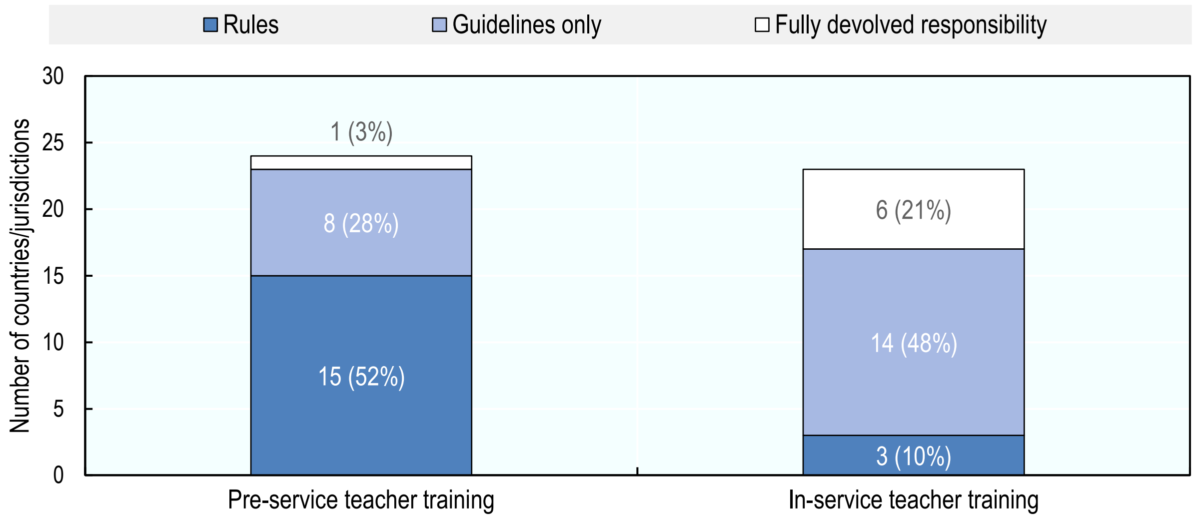
Many OECD countries recognise that digital competences are amongst the fundamental competences required of all teachers and that these should be developed throughout their formal education and training. However, significant differences exist across education systems in terms of how standards on teacher digital competences are defined, set and regulated. These include: 1) the context in which teacher digital competences are expected to be developed (e.g. pre-service or in-service teacher training); 2) how teacher digital competences are defined and organised within applicable rules and guidelines (e.g. broad aspirational statements to specific descriptions of practice); 3) how rules and guidelines are implemented (i.e. the specific policy levers used), including the extent to which they are proactively enforced; and 4) the extent to which teachers' digital competences are formally evaluated.

Figure 7.3. A snapshot of rules and guidelines on developing teacher digital competences



Note: N=29

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In over half of the 24 education systems that define some professional standards on teachers' digital competences, these are enshrined into national laws for pre-service teachers (15 countries, see Table 7.1). In nearly all cases these laws refer to teachers at all education levels (including VET) and they typically form part of broader regulations describing the minimum standards of practice for trainees to achieve qualified teacher status. In contrast, only three countries have national regulations about the digital competences of in-service teachers; where they do exist, these typically also refer to teachers at all educational levels and form part of broader regulations defining the criteria for systematic teacher evaluations. Most OECD countries tend to provide national guidelines only on the digital competences of in-service teachers or devolve this responsibility to lower levels of government. This may allow greater flexibility for local authorities to define their own priorities and standards for teachers that better respond to their specific needs and contexts.

Setting teacher standards provides important signalling about the desired competences of educators. Their formulation also usually involves a consultative process involving key education stakeholders, including teacher unions and teacher education providers. Including digital competences within teacher professional standards can therefore establish shared expectations and understanding amongst important stakeholders and promote or regulate (in the case of rules) their development. However, high-level rules and guidelines do not always translate into concrete development opportunities in teachers' formal education and training. The European Commission found that only around half of European education systems formally link rules (where present) on teacher digital competences with the contents of initial teacher education programmes in their countries (European Commission/EACEA/Eurydice, 2019[14]).

The lack of relevant opportunities for student teachers to develop their digital competences as part of their formal initial education and training is also reflected in OECD TALIS data: in 2018, on average across the OECD, only 56% of lower secondary teachers surveyed had received any pre-service training in the use of ICT for teaching. Although this proportion tended to be significantly higher among more recent teacher cohorts of teacher, in some countries (including Austria, Czechia, Denmark, Iceland, Korea, Norway and Portugal) more than 25% of teachers who had completed their initial training within five years of the survey reported not to have received any training in the use of ICT for teaching (OECD, 2019[2]). Across all OECD countries, less than half of lower secondary teachers reported feeling prepared to use ICT for teaching after completing their initial education or training.

Several reasons might explain the gap between formal rules and guidelines on developing digital competences and the reality of teacher training and classroom practices. In general, directives on professional standards remain broad and high-level, neither imposing a common curriculum for initial teacher education providers or specifying content areas nor a minimum instruction time related to developing digital competences. This, together with the academic freedom of higher education institutions in many countries, mean that teacher education providers often have significant autonomy to shape their course offering and how it should be delivered to student teachers including the extent to which digital competences are a focus of teacher education programmes. In addition, a general lack of systematic evaluation and/or assessment of teacher digital competences in the context of both pre- and in-service teacher education may lead to less attention being paid to developing these skills.

Another reason may stem from the fact that teacher digital competences tend to be addressed in rules and guidelines as one of several transversal competences that should be developed across the whole programme of initial teacher education and throughout teachers' professional careers. While this is a valid and appropriate aim, it can leave room for ambiguity in how stakeholders understand, develop and evaluate these skills in practice. Some countries have thus complemented broader teacher regulations or standards with detailed competence frameworks that explicitly describe the intended knowledge, skills, attitudes and values of educators. Such documents are intended to further guide stakeholders within the education system including policy makers, initial teacher education and teacher training providers, school leaders and evaluators, and current and prospective teachers (European Commission/EACEA/Eurydice, 2019[14]).

Some European countries (Austria, Estonia, Ireland, Lithuania and Spain) have developed separate teacher digital competence frameworks for all teachers rather than integrating digital competences in more general teacher competence frameworks (see Box 7.1). Often these have been adapted from existing international frameworks describing teacher digital competences, such as DigCompEdu: The European Framework for the Digital Competence of Educators (Redecker, 2017[5]) or UNESCO's ICT Competency Framework for Teachers (UNESCO, 2018[6]).

Dedicated digital competence frameworks may help to signal teacher digital competences as a priority development area as well as provide more detailed guidance on how to develop them – especially where frameworks include progression models that can map to teacher evaluation and certification processes. A dedicated approach also has the advantage of greater policy agility as new digital innovations continue to emerge (e.g. generative Artificial Intelligence): updating these frameworks does not involve reviewing the entire set of teacher competences. However, separating digital competences from other important teacher competences may give the impression that the former are disconnected from "regular" pedagogical approaches, rather than considered integral to and interconnected with other teacher competences.

Box 7.1. Examples and uses of teacher digital competence frameworks

The “Digi.kompP” model, Austria

The “Digi.kompP” digital competence model, developed by the University College of Virtual Teacher Education on behalf of the federal ministry in Austria, provides a framework for eight digital competence areas.[1] It also provides a progression model divided into three professional development phases: Phase 1 starts from before entry into initial teacher education (aligning with the expected digital competences that all students should have after finishing general education), and Phase 3 extends into the end of the fifth year of the profession. The “Digi.kompP” model serves to categorise digital skills courses at teacher education universities and guides teachers’ self-assessment and professional development.

Spanish Framework for the Digital Competence of Teachers, Spain

Spain’s recently updated “Spanish Framework for the Digital Competence of Teachers” (INTEF, 2022[15]) complements national rules on the accreditation of initial teacher education providers for primary and secondary education (BOE, 2007[16]; 2007[17]). While the latter regulations refer to developing teacher digital competences in general terms only, the framework describes the knowledge, abilities and attitudes required for the six digital competence areas and 23 digital sub-competences in detail. The framework also defines a progression model with six proficiency levels that are similar to those of the European Union’s language proficiency framework (e.g. level A1 through to C2) and are used to certify the digital competence of in-service teachers.

The “Digital Learning Framework”, Ireland

The “Digital Learning Framework” for primary and secondary education describes the desired and effective practices of students and teachers while using digital technologies for teaching and learning. The framework is divided into four domains: two refer to students – Learner outcomes and Learner experiences – and two refer to teachers – Teachers’ individual practice and Teachers’ collaborative practice. The statements aim to help teachers and school leaders identify, prioritise and chart areas of improvement as well as identify continuing professional development needs.

Linking teacher standards to accreditation processes for initial teacher education providers

Rules and guidelines on teacher professional standards can serve to establish criteria for awarding institutional accreditation to teacher education providers. Formally linking rules and guidelines on teacher digital competences to accreditation processes is one way to balance respecting institutional autonomy with ensuring student teachers have access to opportunities to develop digital competences as part of their pre-service education and training. For example, rules may require education providers to include mandatory or elective courses on digital pedagogies as part of any initial teacher education programme or to focus a minimum number of instruction hours on the topic. This approach to regulating teacher education still allows some flexibility for providers, such as being able to define the exact content, method of delivery, and evaluation of courses. While accreditation does not always guarantee quality in delivery, including teacher digital competences within accreditation criteria ensures that at least some attention will be paid to developing student teachers’ digital competences in their initial teacher education and can promote equal opportunities for student teachers to access formal training on the topic.

Some OECD countries already link standards on teacher digital competences with accreditation processes for teacher education providers. For example, in Lithuania, regulations issued by the Ministry of Education, Science and Sport address the mandatory contents of initial teacher education programmes and requirements for developing and certifying the digital competences of teachers and student support specialists (TAR, 2018[18]). In Ireland, the Teaching Council (the national body responsible for initial teacher education accreditation) previously included "ICT in Teaching and Learning" as one of 15 mandatory elements that must be included in all initial teacher education programmes to get accreditation (Eurydice, 2023[19]). In its updated standards, published in 2020, digital skills are considered one of seven "core elements" that should underpin all aspects of all initial teacher education programmes (The Teaching Council, 2020[20]). All existing and new primary and post-primary education programmes submitted to the Council for accreditation must align with the updated standards as of September 2022. Similarly, in Scotland (United Kingdom) and Wales (United Kingdom), guidelines for initial teacher education accreditation specify that programmes should include opportunities for student teachers to enhance their digital literacy skills and practice digitally supported pedagogies (The General Teaching Council for Scotland, 2019[21]; Welsh Government, 2018[22]).

Linking teacher standards to the evaluation or certification of teacher digital competences

Rules and guidelines on teacher digital competences can also provide criteria for formal evaluation or certification processes – especially when they refer to detailed competence descriptions and progression models. There are several different policy levers that can be implemented to formally evaluate teachers' digital skills in some capacity. These include formal assessments as part of teacher qualification processes, certification opportunities during pre- or in-service training, or the systematic evaluation of in-service teachers' competences through external or internal school evaluation.

Integrating formal assessments of digital competences during or at the end of initial teacher education programmes can provide an inherent incentive to teacher education providers and future teachers to develop these skills. However, only a minority of countries include mandatory requirements to assess teachers' digital competences as part of teacher qualification processes (see Box 7.2). Formal assessments could take different forms, for example via a standardised examination or through obtaining certification that they graduated from a teacher education programme that evaluated those skills. Teacher digital competences might also be formally evaluated as part of teacher trainee practical training requirements (i.e. in their first employment role before transitioning to fully qualified teacher status).

Alternatively, providing prospective teachers with optional certification opportunities during their pre-service training can also incentivise student teachers to develop their digital competences. Although they are not formally assessed as part of teacher qualifications in Denmark, the country does offer a voluntary pedagogical ICT licence (*Pædagogisk IT-kørekort*) that combines pedagogical knowledge of ICTs and basic ICT skills training. The licence was first implemented for in-service training in the 1990s but was subsequently integrated as a voluntary element into the curriculum of student teachers in teacher education colleges (Rizza, 2011[23]).

Beyond initial teacher education, evaluating or certifying teacher digital competences can serve to identify skills gaps, foster skills improvement, and incentivise the provision of relevant professional development. However, few countries systematically certify the digital competences of in-service teachers. A notable exception is Spain: in 2022, the National Institute of Educational Technologies and Teacher Training (a national education agency) published the updated "Spanish Framework for the Digital Competence of Teachers" for certifying in-service teachers' digital skills and which defines proficiency levels ranging from A1 (novice) through to C2 (mastery) levels (INTEF, 2022[15]). Each autonomous region in the country has adopted the national framework despite education matters largely being a devolved responsibility. Each region is responsible for implementing its own certification process based on a set of common national procedures that have specific requirements differentiated by proficiency level; all certifications that are issued in the country are thus recognised in all other regions and at the national level (BOE, 2022[24]). For example, certification for levels A1 and A2 may be awarded after any of the following procedures: 1) participation in teacher training activities (with a minimum number of hours and content areas covered); 2) passing a test (that includes questions corresponding to at least 80% of the relevant indicators from the framework); or 3) obtaining a teacher degree specialised in digital technologies. Certification is voluntary for teachers, but each region has committed to certifying at least 80% of in-service primary and secondary teachers before the end of 2025. As a result, some educational authorities have engaged in comprehensive efforts to foster and support the development of teacher digital literacy in their respective autonomous regions and cities (see Box 7.3), including the national Ministry of Education in the autonomous cities of Ceuta and Melilla.

Box 7.2. Different approaches to assessing prospective teachers' digital competences

Assessing digital competences before entry to the profession as student teachers

…through a competitive or standardised examination

In Italy, prospective general secondary education teachers must pass a competitive examination after completing their initial teacher education to obtain their qualification and access jobs within the profession. Similarly, prospective teachers willing to teach at primary and secondary levels (in public and private government-dependent sectors) in France also enter the teaching profession by taking a contest, which can take different formats depending on the student teacher's pathway. While both countries have rules (Italy) and guidelines (France) respectively on developing teacher digital competences, it is not clear to what extent these are systematically assessed in the competitive examinations. Integrating items with a focus on teachers' digital skills would enable applicant teachers' digital competences to be explicitly tested and would further incentivise initial teacher education providers and student teachers to develop these skills.

…to fulfil teacher registration requirements

In Australia and the United States, while processes vary state by state, in general teachers must be registered or certified to enter the profession and digital competences is often one component of the registration or certification criteria. In many cases, registration or certification relies on obtaining formal teacher qualifications granted by an accredited (or recognised) initial teacher education programme; this may sometimes be further supplemented by completing some practical experience or obtaining other supporting documentation. Formally linking standards and assessment criteria on teacher digital competences to teacher education accreditation processes would further strengthen this approach.

Assessing digital competences after entry to the profession as teacher trainees

In Slovenia, trainee teachers must develop digital competences during their professional induction period. A mentor evaluates the trainee's developing competences for independent teaching, including their digital pedagogical competences, and provides a summative report at the end of the period of evaluation. The written report is then considered as one of the necessary supporting documents when trainee teachers apply for the state professional examination to obtain their full teaching qualification.

Box 7.3. Regional efforts to develop and certify teacher digital competences in Spain

All of the educational administrations in Spain, both at the central and regional level, have agreed on the processes for the certification, accreditation and recognition of teacher digital competences. With this aim, several regional educational authorities have developed tools and initiatives to promote and facilitate the certification process in line with the national "Spanish Framework for the Digital Competence of Teachers" (INTEF, 2022[15]) and with the options available to certify teachers at different proficiency levels. For example, the regional ministry in Aragón has developed its own teacher digital competence strategy and established specific roles (digital mentor and tutors) to support teacher training and certification (BOA, 2022[25]). Once certified, teachers' data is stored in Aragón's teacher management platform (*PADDOC*), which recommends further training courses and materials to teachers through the region's teacher training platform (*Doceo)*.

In Madrid, the regional ministry is creating a dedicated platform for assessing and certifying teachers' digital competences (*MADIGITAL*). Currently, only examinations at lower and intermediate proficiency levels are available. To support teachers to transition to higher proficiency levels, the ministry has created an online portfolio tool for teachers to document professional development activities related to digital education and demonstrate the evolution of their digital skills.[2] The government of the Canary Islands has also developed a dedicated teacher training platform on digital education with various resources enabling teachers to access training modules and technical support and certify their digital competences, as well as develop further guidelines on teacher professional standards.[3]

In Andalusia, the ministry administers a survey to teachers via its teacher and school management platform (*Seneca*), with questions mapped to the relevant content areas and proficiency levels of the national framework. The ministry publishes reports examining the aggregated data including breakdowns of teacher self-reported competences in each of the region's provinces.[4]

Systematic evaluations of teacher digital competences may be more common than certification, but a further way to promote the development of teacher digital competences is to strengthen their relevance within external and/or internal school evaluation criteria. School evaluation plays an important role in teacher development and classroom practices by incentivising teachers to improve their performance. While specific evaluation procedures vary, schools in most countries tend to undergo some periodic evaluation by public inspection authorities whose reports are usually made publicly available (OECD, 2013[26]; OECD, 2015[27]). An opportunity therefore exists for policy makers and administrators to shape evaluation frameworks to raise standards and target specific areas of school education, including digital education and teacher digital pedagogical competences.

External evaluations and reports are increasingly addressing issues around digital education, including the use of digital technologies for teaching and learning (OECD, 2023[28]). In Slovakia, for example, the State School Inspectorate's evaluation framework includes the use of digital technologies for teaching as an explicit criterion for the evaluation of education facilities and resources in schools (European Commission/EACEA/Eurydice, 2015[29]). Likewise in Scotland (United Kingdom), school inspections now include a focus on the effective of digital technology for learning (Scottish Government, 2016[30]). A greater emphasis in school evaluations on certain aspects of teaching using digital technologies may also then be linked to a greater emphasis on these aspects in teacher appraisal and feedback processes; in turn, this can incentivise further changes in teaching practices.

Setting standards for student learning outcomes

A different approach to fostering teacher digital competences within the broader context of setting standards is to focus on student learning outcomes. Of the 29 OECD countries and jurisdictions that participated in our comparative study, nearly all have national rules and guidelines on developing students' competences to use and understand digital technologies (Table 7.2 and Figure 7.4). Expecting students to develop digital competences as a core part of their education implies that they should be taught by capable educators with appropriate skills themselves – especially in countries where digital competences are considered a transversal student learning outcome that is the responsibility of all teachers, or where there are no requirements for technology-related courses in the curriculum to be taught by specialist teachers. Notably, more OECD countries and jurisdictions have national rules and guidelines on developing student digital competences than they do for developing teacher digital competences (see Table 7.1 and Figure 7.3 for comparison). Only 3 countries (Mexico, the Netherlands and Türkiye) do not have any national directives on developing student digital competences (although these may nonetheless exist at lower levels of government).

Rules or guidelines on developing students' digital competences tend to apply to all educational levels, but some countries do not include VET in these provisions. Despite the relative lack of regulations or guidance on digital education in VET, TALIS data show that a significant proportion of upper secondary VET teachers do frequently use digital technologies with their students, and more so than general secondary teachers (OECD, 2021[31]). One reason for this discrepancy may be that when the use of digital technologies is natural to the subject content (such as in VET), their use is integrated into classrooms regardless of whether it is mandated or not. As work environments continue to digitalise, VET teachers need to equip their students with vocational and digital skills to facilitate their transition into the labour force and enhance their adaptability. Innovative technologies like robots, virtual reality and augmented reality, and simulators will also likely become more common in VET in the years to come, and teachers' effective use of these technologies is therefore important for fostering students' foundational vocational skills (OECD, 2021[31]). Setting standards on developing student digital skills or specific uses of technology may thus be more relevant in contexts in which doing so may be perceived as optional rather than a necessity.

Approaches vary across countries in terms of how digital competences are integrated into national curricula. In almost all systems, digital competences are recognised as transversal competences that should be integrated and developed across subjects. In effect, this means that in most countries all general education teachers are considered responsible to some extent for developing students' digital competences – although very few systems formally evaluate students' digital skills to incentivise teachers (see Box 7.4). In several countries, schools have significant autonomy to decide how to interpret the national curriculum guidelines and integrate digital competences within their educational offering (e.g. as integrated content or as a distinct area of study). Similarly, in federal or devolved countries and jurisdictions, often lower levels of government (e.g. state or regional) will have further rules or guidelines on the curriculum in addition to national directives.

A few systems (including the French Community of Belgium, Hungary, Iceland, Korea and Latvia) do have rules on teaching student digital competences as a distinct subject area in the curriculum in addition to integrating digital competences across all subject areas. For example in England (United Kingdom), digital competences are addressed primarily via the dedicated subject area of computing (which encompasses computer science, ICT and digital literacy), which is a compulsory subject in the national curriculum at both primary and secondary levels (ages 5 to 16 inclusive).[5] Students in upper secondary are also able to pursue a (further) computer science qualification that forms part of their qualifications at the end of compulsory schooling. While a distinct subject area approach may be more effective in terms of achieving student outcomes, it is less likely to encourage all teachers to develop their own teacher digital competences as the responsibility for students' skill development may be transferred primarily to the subject area teachers.

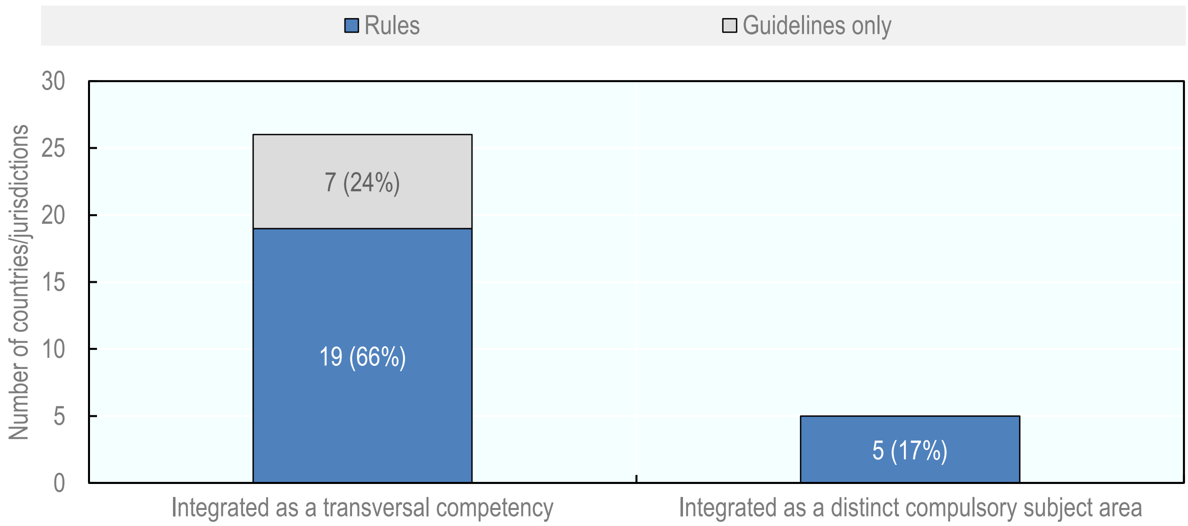
Table 7.2. Rules and guidelines on integrating digital competences in the curriculum

Country/jurisdiction	Integrated as a transversal competence		Integrated as a distinct, compulsory subject area
	Rules	Guidelines only	Rules
Austria		✓	
Brazil	✓		
Canada		✓	
Chile	✓		
Czechia	✓*		
Denmark	✓*		
Estonia	✓		
Finland	✓**		
France	✓		
Hungary	✓*		✓*
Iceland	✓**		✓
Ireland		✓*	
Italy	✓*		
Japan	✓		
Korea	✓**		✓**
Latvia	✓		
Lithuania		✓	
Luxembourg	✓		
Mexico			
Netherlands			
New Zealand		✓*	
Slovenia		✓	
Spain	✓		
Sweden	✓		
Türkiye			
United States		✓	
England (United Kingdom)	✓		✓
Flemish Comm. (Belgium)	✓		
French Comm. (Belgium)	✓**		✓**
Total (29)	**19**	**7**	**5**

Note: ✓ denotes rules or guidelines at all educational levels. ✓* denotes rules or guidelines at all educational levels excluding VET (i.e. primary, lower secondary and upper secondary education). ✓** rules or guidelines at primary and lower secondary education only (i.e. excluding upper secondary and VET).

StatLink https://stat.link/5bkxnm

Figure 7.4. A snapshot of the rules and guidelines on integrating digital competences in the curriculum



Note: N=29.

StatLink https://stat.link/0nxhzp

Box 7.4. Supporting the development of digital competences through assessment

Assessment serves an important role in education systems, both for monitoring and evaluation purposes but also to signal intended learning outcomes. Assessing student digital competences can thus strongly incentivise the development of both student and teacher digital competences. No OECD education systems in our comparative study reported formally assessing students' digital competences via a summative or standardised examination, despite the majority recognising the importance of developing these skills across the curricula (Table 7.2). However, in France, students must now sit and pass the PIX self-assessment as part of their final lower secondary school exams (*Diplôme national du brevet*), for which they obtain a digital certification.

While no OECD countries have national examinations of students' digital skills, a few do use low-stakes or self-assessment tools to evaluate student digital competences and serve formative purposes. In Estonia, for example, the Foundation Innove worked with university researchers to develop digital skills assessments for students in grades 9, 12 and upper secondary VET, following which students are able to receive verbal feedback on their performance (OECD, 2020[32]).

Some European countries have also developed online diagnostic tools to help teachers evaluate their digital competences, identify knowledge and skills gaps, and direct them towards further professional development content. In many cases, these tools have been adapted from the EU's "SELFIE for Teachers" tool (e.g. *DigiSnap* in the Flemish Community of Belgium, *Profil Učitel21* in Czechia). Similarly to the student self-assessment tool used in France, teachers in initial teacher education in the country can obtain a certification of their digital competences via the *PIX-EDU* tool (also an adaptation of "SELFIE for Teachers").

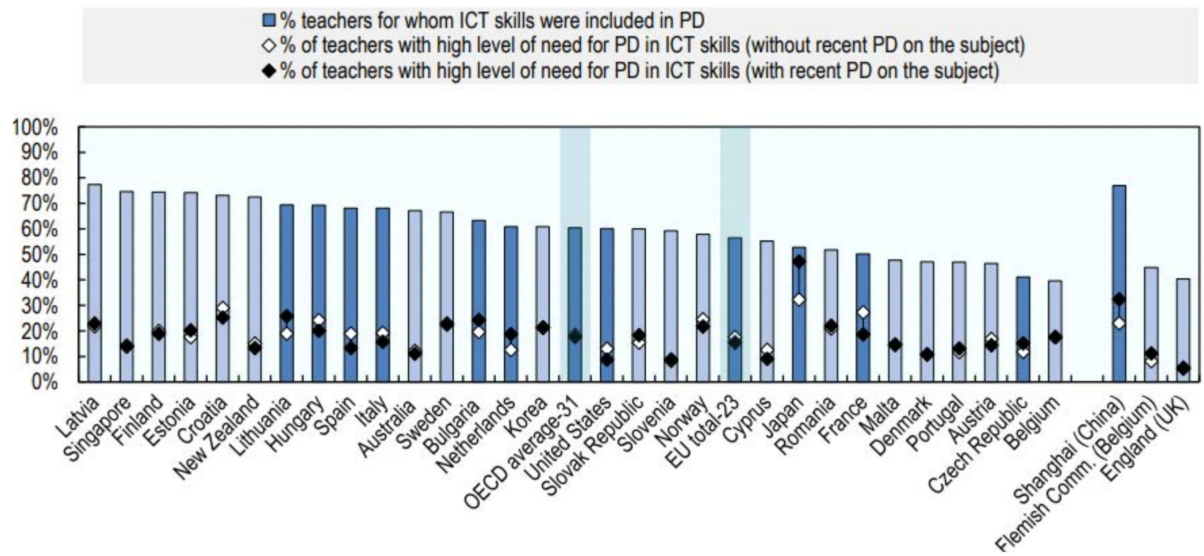
Incentivising professional development on digital competences

Standards on teacher and student digital competences formally articulate their importance to a variety of education stakeholders and can serve to mandate or incentivise a variety of actors – teacher education providers, schools, and individual teachers – to focus on developing them. However, setting standards is not the only approach to formalising teacher digital competences. In many countries, participation in some form of continuous professional development is a compulsory activity for teachers, either as a general condition for continued employment or for career advancement (OECD, 2016[33]). Continuous professional development is also vital to broaden and deepen teachers' practical and theoretical knowledge, help them keep up with new research, tools and practices, and respond to students' changing needs (Boeskens, Nusche and Yurita, 2020[34]).

Evidence from international surveys suggest that teachers' participation in relevant training is positively associated with teachers using ICT in their classes more frequently and feeling confident in supporting students with digital technologies (Gil-Flores, Rodríguez-Santero and Torres-Gordillo, 2017[35]; Fraillon et al., 2014[36]; OECD, 2020[37]; Minea-Pic, 2020[38]; European Commission, 2013[39]). TALIS data (prior to the COVID-19 pandemic) also show that, on average across OECD countries, there is a high perceived need for further training in ICT among general secondary education teachers despite relatively high levels of participation in professional development in this area (OECD, 2019[2]). Among the 60% of teachers on average across the OECD who reported engaging in professional development on ICT skills for teaching during the year preceding the TALIS survey, nearly two in 10 (17.6%) reported a high need for further training – a proportion only marginally lower than those who had not participated in any ICT-related training in the same period (Figure 7.5). This shows that a significant proportion of teachers perceive a need for further continuous professional development in this area. Anecdotal evidence during and after the COVID pandemic also confirmed this impression, even though the effects of global school closures and remote learning arguably led teachers to develop their digital skills significantly.

Figure 7.5. 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 shown in a darker tone.
Source: OECD (2019[2]), *TALIS 2018 Results (Vol. I): Teachers and School Leaders as Lifelong Learners*, https://doi.org/10.1787/1d0bc92a-en, Table I.5.24.

StatLink https://stat.link/ef5ykq

In most systems, educators can choose which professional development activities to engage in; training on ICT and digital pedagogies may therefore be just one of several possibilities available to them. This can make it difficult for countries to accelerate the upskilling of in-service teachers' digital competences. In Italy, from the current 2023-24 school year onwards, in-service teacher training on digital skills is compulsory in an effort to bring about the large-scale upskilling of its teacher force. Teachers' participation in relevant trainings must take place outside of their regular teaching hours but costs are covered through a central government fund, and a new dedicated teacher development platform has been developed to deliver online training courses (see Box 7.6 for more). However, there is little evidence to date about the effectiveness of mandating professional development on digital competences for improving teacher practice and agency above other incentive-based approaches. Making professional development on a particular area an obligation requires that quality training opportunities are available and accessible to all educators to avoid exacerbating existing digital divides within the teacher profession, as well as accompanied by adequate funding (OECD, 2019[40]; OECD, 2019[41]). It would also have to be balanced against other areas of teacher training.

According to TALIS data, the second-highest reported barrier to participation in professional development for teachers (48% on average) and school leaders (35% on average) respectively is the lack of sufficient incentives (OECD, 2019[2]). In general, teachers may benefit from different sorts of incentives to participate in professional development activities including financial rewards, reduced teaching hours, competitions that award prizes, additional training hours and additional equipment for the classroom (Wastiau et al., 2013[42]). Beyond these general incentives, other levers may incentivise teachers to develop their digital competences specifically: these include recognising digital skills for career advancement, developing accessible and flexible training content, and combining financial and structural incentives to engage in professional development on digital competences.

Recognise digital competences for career advancement or specialisation

Some countries have designed new reward and promotion structures within the teaching profession to reflect educators' digital skills development, as evidenced through participation in accredited trainings, certification or teacher appraisal. For example, in Croatia, sharing innovative teaching methods or creating digital content are listed as evaluation criteria for primary and secondary school teachers, teaching assistants and school principals (Ministry of Science and Education, 2019[43]). Among other aspects, these criteria determine the allocation of annual awards for teaching excellence and are used to assess educators' eligibility for career progression (Ministry of Science and Education, 2023[44]).

Some countries have also designed new career pathways that offer both vertical and horizontal opportunities for professional growth related to digital skills development. In the Slovak Republic, teachers can have a career that is both differentiated vertically (e.g. beginning teacher, independent teacher, teacher with first certification, etc.) and horizontally, with the latter enabling them to take on specialist positions such as an ICT coordinator and devote more time to developing skills in their specialist area (OECD, 2019[41]). Similarly in Czechia, teachers can become a dedicated "ICT methodologist" in their school tasked with helping colleagues to integrate digital technologies in their teaching and to create their school's digital strategy. This role has state-recognised concessions in teaching duties and teachers in the role must complete specific trainings. Several other countries have created "digital ambassador"-type roles that teachers can choose to evolve into to help coordinate and promote digitalisation efforts in their schools.

Digitalisation itself can also offer new opportunities for recognising teachers' invested time, effort and acquired skills in a range of areas, including their digital competences. New methods and tools, like open badges or micro-credentials, have emerged for certifying and recognising a variety of skills. Micro-credentials enable teachers to choose a specific skill they wish to develop or have recognised, engage in some instruction (often online) and practice activities, gather the evidence underpinning their mastery of the skill (e.g. through e-portfolios), and have it recognised by a reviewer in a credentialing platform (Minea-Pic, 2020[38]). For example, in Spain, the National Institute of Educational Technologies and Teacher Training has developed several self-learning activities that are offered through a mobile application called "EduPills" as a complement to the various other tutored courses, Massive Online Open Courses (MOOCs) and blended training activities they offer (see Box 7.6). The "EduPills" activities are mapped to the different competence areas of the "Spanish Framework for the Digital Competence of Teachers" (INTEF, 2022[15]) and individuals can store, export and share the digital micro-credential badges they earn via their social networks.

While micro-credentials can provide some external recognition of skills development for motivated teachers, they may not be enough to incentivise the majority teachers to develop their digital competences unless these emerging forms of certification can be recognised as part of formal professional development requirements that matter for career progression and compensation. In the United States, some states have enabled educators to use micro-credentials specifically designed for teachers to fulfil their continuing education and professional development requirements in this way (see Box 7.5).

Box 7.5. Integrating micro-credentials into formal professional learning structures

Digital Promise is an independent organisation authorised by the United States Congress to act as the National Centre for Research in Advanced Information and Digital Technologies. It has developed over 450 micro-credentials for early childhood education, school education, higher education and adult learning that are provided by more than 50 organisations (e.g. higher education institutions, non-profit organisations, school districts) around the country (Brown, 2019[45]). The offer includes a range of education programmes leading to credentials in varied areas such as assistive technologies, digital literacy, digital citizenship, technology planning and virtual reality.

Digital Promise offers micro-credentials directly to teachers but closely collaborates with schools and districts on the design of teacher professional learning structures based on micro-credentials: in some cases, educators who participate in Digital Promise micro-credential programmes can earn continuing education credits with their employing state or district; other states have experimented with using 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[38]; DeMonte, 2017[46]).

Harness digitalisation to make available accessible and flexible resources and training

In addition to providing new certification opportunities, digitalisation can deliver new forms of flexible professional development activities that can potentially reach a greater number of teachers – especially those whose participation in professional development activities typically occurs outside of their normal working hours. Data from the OECD Survey of Adult Skills show that teachers are far more likely to engage in open or distance education outside of their working hours compared to other tertiary-educated workers (OECD, 2017[47]). The online delivery of professional development activities can also be coupled with new opportunities to expand teacher-centred collaborative learning in the virtual space and personalise training content (Minea-Pic, 2020[38]). However, as with any professional development activities, online training content needs to be carefully designed and research on the characteristics of effective online activities such as Massive Online Open Courses (MOOCs) for teacher professional learning are still emerging (Minea-Pic, 2020[38]).

Box 7.6. Professional development platforms to support teacher digital competences

Digi.folio, Austria

The *digi.folio* platform in Austria provides personalised learning activities for educators based on the country's "digi.kompP" teacher digital competence framework. The platform provides teachers with a diagnostic tool (digi.checkP) that gives them feedback on their current proficiency level before providing them with a 50-unit, tailor-made training course based on the results. Teachers can search for courses from any of the country's teacher universities via the platform and, once completed, their activities are stored in a digital portfolio. Teachers can also generate certificates of proficiency that can be confirmed by their school management during a reflection meeting.

Réseau CANOPÉ, France

The ministry in France operates the *Réseau CANOPÉ*, initially an online platform for teacher development on digital pedagogies but that now includes several tools and services for teachers on various aspects related to digital education. The *Réseau CANOPÉ* network brings together: *Canotech* for in-service teacher training, *m@gistère* for tutoring, BSD for accessing a bank of best teaching practices, *TICE* for help on integrating digital practices into teaching, and *Quizinière* for creating interactive digital activities, among other tools and services.

Scuola Futura, Italy

To support new mandatory professional development requirements on digital education, Italy created the *Scuola Futura* platform to deliver online trainings to school staff on a variety of topics related to digital pedagogies and school digitalisation. The platform complements the country's other teacher professional development platform (*SOFIA*) that teachers can use to access online professional development courses on a range of other topics from different government-approved providers.

Knowledge Spring, Korea

Following the COVID-19 pandemic, the ministry in Korea created the *Knowledge Spring* teacher training and resource platform to support teacher digital competences, including for remote teaching. Teachers can develop and offer training programmes via the platform to their fellow teachers in real time or take trainings provided by their colleagues. The courses and trainings are flexible so that teachers can participate according to their own schedule. The ministry also operates a separate section within the platform focused on providing training to teachers on specific EdTech tools (as selected by the ministry).

AprendeINTEF, Spain

The National Institute of Educational Technologies and Teacher Training in Spain provides most of its professional development activities online via the *aprendeINTEF* platform, including Massive Online Open Courses (MOOCs), Nano-MOOCs and tutored courses. Courses focus on developing teacher digital skills, implementing digital pedagogies, or designing digital learning resources. The online tutored courses last two months and encompass around 60-70 hours of training, with expert tutors and coordinators guiding participants. The course catalogue is updated yearly and teachers receive a certification for the training hours undertaken upon completion. For the MOOCs and Nano-MOOCs, training hours are not certified but teachers can earn digital micro-credentials: these can be stored in an "Open Badge Backpack" that teachers can use to import, store and share (via social media) their micro-credentials earned on various systems, including the micro-learning app *Edupills*. Digital meta-credentials recognising learning paths can also be issued after collecting several micro-credentials.

Many OECD countries do currently support teacher professional learning through integrated professional development platforms (see (Yu, Vidal and Vincent-Lancrin, 2023[1]), Chapter 5, for more information on public MOOCs platforms). Educators can typically use these platforms to access content like online training courses, information resources, MOOCs and webinars on a range of digital education matters. In most cases, these platforms include some content on developing teacher digital competences as part of a broader range of professional development areas – although some countries have developed dedicated platforms exclusively focused on developing teacher digital competences (see Box 7.6). While face-to-face training and activities should remain important components of teachers' continuous professional development offer, online platforms can provide a flexible and accessible complement.

Provide strong financial incentives

Strong financial incentives for participating in professional development helps to support teacher autonomy and flexibility. The removal of financial barriers enables teachers to choose to develop the skills they need the most rather than make choices guided by avoiding financial penalty. Some countries allocate a yearly budget to support professional development on digital competences, which can be used to cover the compensation of teachers (either in lost earnings or in training costs) or to incentivise schools with grants to support teacher training in this area. For instance, the ministry in Latvia has subsidised professional development courses on ICT for teachers. Other countries have designated digital education as one of a few priority areas for teacher professional development combined with financial incentives. For example in Italy, prior to mandating professional development on digital skills, the ministry allocated EUR 1.5 billion for educator training in several priority areas including digital education: teachers were given EUR 500 per year via an electronic "Teachers' Card" to participate in training activities within the designated priority areas and to purchase resources (books, software and hardware, conference tickets, etc.) (OECD, 2017[48]). In New Zealand a similar approach exists but also balances national and local priorities. "Digital fluency" is one of seven national priorities for teacher professional development in both English- and Māori-medium settings that the ministry funds.[6] While priority areas are designated nationally, each funding application is evaluated and approved by regional panels to ensure alignment between the diverse needs and contexts of teachers and schools with key system-level challenges.

Financial incentives can also target the institutional level to foster improvements in their educational offering (i.e. for teacher education providers) or enhance their digital infrastructure. One initiative in Germany to enhance the quality of initial teacher training (Qualitätsoffensive Lehrerbildung, 2014-23) and offer more targeted support for specific topics was a funding competition scheme, where universities providing initial teacher education programmes across the country could apply for and receive funding for projects. Following an interim review of the initiative in 2018, a new funding stream for the digitalisation of initial teacher education was introduced for the second phase (2019-2023) (OECD, 2020[49]).

Creating of a wider digital education ecosystem to support education stakeholders

Creating a wider ecosystem of support for digitalisation in education can help to coordinate different efforts amongst the many stakeholders involved in developing teacher digital competences and help to provide more holistic support for teachers to integrate digital technologies into their teaching practices. One clear way that countries have formalised a whole-system approach to developing teacher digital competences is by creating designated national or centralised agencies whose responsibility is to develop policy, coordinate national initiatives and innovation projects, and promote teacher professional learning in the context of digital education (see Box 7.7 and (Dellagnelo, 2023[50]) for further examples).

Box 7.7. Specialised national agencies on digital education and professional development

Digisprong Knowledge Centre, Flemish Community of Belgium

Digisprong ("Digital Jump") is the Flemish Community of Belgium's digital education strategy, initiated during the COVID-19 pandemic. The strategy established the Digisprong Knowledge Centre, whose role is to provide a focal point for school leaders, teachers and ICT coordinators in Flemish schools. It supports stakeholders by providing expertise in digital education and facilitating peer-learning and cooperation between schools and external actors. The centre also now houses previously existing networks focused on digital education matters such as *KlasCement*, an open educational resources network led and initiated by teachers.

Knowledge Centre for IT in Teaching, Denmark

The Knowledge Centre for IT in Teaching promotes the use of digital technologies in VET and offers professional development courses for teachers in Denmark. It has also established a network of pedagogical staff and school 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 work with several VET schools to support teachers to operate virtual reality equipment and robots and incorporate them into their teaching practice (OECD, 2021[31]).

Oide, Ireland

The government in Ireland supported the integration of digital technologies in teaching and learning through the specialised Professional Development Service for Teachers (PDST) "Technology in Education" initiative. Both that initiative and the broader PDST agency have recently been merged with other organisations to form Oide, a new comprehensive professional development service for teachers. The Digital Technology Division of Oide is now the dedicated service providing digital technology-related support to teachers and schools, including support for digital learning planning and practice, online and face-to-face courses, workshops and seminars, access to best practices resources, and infrastructure, device, networking and technical guidance for schools.

National Institute of Educational Technologies and Teacher Training, Spain

The National Institute of Educational Technologies and Teacher Training (INTEF) is the body responsible for the integration of digital technologies and teacher training across the country, despite education in Spain largely being a devolved responsibility of the autonomous regions. It coordinates four main types of activities: 1) developing and providing open educational resources; 2) delivering professional development activities to promote teacher digital competences; 3) promoting digital education to different stakeholders (teachers, schools, students and parents) through initiatives and guidelines; and 4) coordinating teacher collaboration and innovation. The institute maintains a comprehensive website that hosts different resource platforms, online trainings and applications, as well as guidelines and resources on the various projects it coordinates. It also works closely with the governments of the autonomous communities to coordinate national initiatives and share best practices.

Dedicated knowledge centres and/or professional learning organisations on digital education can provide visible and specialised focal points for educators wishing to engage in professional development and build their capacity in digital teaching and learning. They can provide access to formal professional development activities (e.g. training courses, certification and evaluation processes) as well as more informal support, such as information resources and informal networks. Specialised institutions can also take ownership of defining, supporting and (where relevant and applicable) enforcing professional standards related to teacher digital competences. Charging such institutions with the mission to develop teacher digital competences and promote quality digital education through both formal and informal measures can help to ringfence funding and resources for digital education, promote good practices, and coordinate various related initiatives at different levels of government.

This may be a particularly effective lever in countries that have highly decentralised education systems, where ensuring the equity of access to digital infrastructure and resources, relevant professional training and development opportunities, and other digitalisation initiatives in education may otherwise be more difficult to achieve. In the United States for example, a highly decentralised education system, the Department of Education's Office of Educational Technology has created a "digital equity and transformation" pledge that it is using to raise the profile of developing digital competences in teacher education.[7] Together with the International Society for Technology in Education, it aims to bring together higher education associations and initial teacher education programmes across the country that share a vision for accelerating change in how to prepare future teachers to be successful in new digital learning environments. By signing the pledge, an education provider can signal their commitment to develop teacher digital competences and expand digital equity and transformation in learning.

In addition to providing a focal point for training and information resources for teachers, in some countries these agencies are responsible for implementing national innovation projects on digitalisation in education. These projects may serve as formal professional learning activities for educators or as broader initiatives to accompany teachers in integrating digital technologies into their classroom practice. For example, in Spain, the National Institute of Educational Technologies and Teacher Training coordinates the country's "Future Classroom Lab" (*Aulas del Futuro*) initiative (a project led by the European Schoolnet network but translated into national contexts in 15 countries by local partners), in collaboration with each of the country's regional ministries and various industry partners. The goal of the project is to promote flexible and easily reconfigurable classroom spaces to encourage teaching and learning through active methodologies and the use of digital technologies. Twenty innovative classrooms are being created for teacher training purposes across the country to give teachers access to different digital tools and technologies (e.g. digital whiteboards, tablet, virtual reality, etc.) in a flexible learning space.[8]

In Italy, between 2020 and 2022, a similar initiative under the same European Schoolnet project was run as a voluntary professional development activity: 28 "Future Labs", modelled as future classrooms with innovative environments for robotics, augmented reality and digital fabrication activities were created across the country to provide educators with experiential training on digital teaching methods. Each Future Lab ran its own modified teacher training programme in conjunction with the respective regional teacher training body.[9]

Wider support initiatives might involve helping teachers to understand and implement new standards or guidelines related to the development of digital competences, such as student curriculum reforms related to digital competences. As new digital content and technologies become integrated in student curricula, and as digital technologies continue to evolve, teachers need support to translate national directives into their classroom practices – especially in systems where student digital competences are expected to be developed across disciplines by all teachers, or where schools have significant autonomy to define their own educational programmes based on broader guidelines. Examples of targeted support initiatives that countries have implemented to support curriculum reform include defining model curriculum frameworks that schools can use, or offering opportunities for schools, teachers and students to participate in projects that support the development of "new" student digital competences at different educational levels (see Box 7.8).

Box 7.8. Supporting teachers and schools to integrate digital competences in the curriculum

Revize website, Czechia

To help schools integrate the new informatics and digital competence areas defined in national curriculum frameworks, the National Pedagogical Institute in Czechia created the *Revize* website containing comprehensive information on the curriculum reform as well as guidance and best practices for its implementation.[10] The ministry also developed a model school educational programme for the new curriculum to guide schools in developing their own programme.

The National Digital School Plan, Italy

Italy's "National Digital School Plan" is the country's main strategy focused on the digital transformation of schools.[11] One of its four key activity areas focuses on enhancing students' digital skills. Several initiatives help schools to integrate relevant content into their educational programmes including: 1) a new digital civic education syllabus to complement the national curriculum and guide schools on how to integrate relevant content into existing courses; 2) the *Programma il Futuro* ("Programme the Future") project that integrates 10 hours of programming into primary education classes; and 3) a short national curriculum on digital entrepreneurship for secondary education.

Supporting the Digital Technologies and Hangarau Matihiko curriculum reform, New Zealand

New Zealand introduced computational thinking and "designing and developing digital outcomes" as new components in its Digital Technologies and Hangarau Matihiko curriculum reform. The government spent around NZD 38 million (USD 24 million) on several initiatives to ensure schools understood the new content areas and how they could be integrated into teaching and learning. These included: 1) new resources on an existing website with curriculum support materials for teachers; 2) a 3-year Digital Readiness Programme to help embed the new curriculum in schools across the country; and 3) various partnerships with external organisations (e.g. universities, IT businesses, public museums) to provide students with access to specialised technologies and learning environments. [12]

Finally, to further support holistic digitalisation efforts at the school level, some countries have encouraged or mandated schools to develop regular school digitalisation plans or roadmaps. These plans require school leaders to periodically map out the different digitalisation efforts within their schools in the short- or medium-term to facilitate a more coherent planning and implementation of initiatives. These plans can also be combined with school self-evaluation exercises or external school evaluations, and often include a component on the development of digital competences of educators and administrative staff. In most countries where these plans are a requirement or strongly encouraged, specific tools have been developed to facilitate their elaboration by school leaders. For example, school leaders in the Flemish Community of Belgium can access an "ICT policy planner" tool provided by the central Digisprong ("Digital Jump") Knowledge Centre that guides them through the process and provides a customisable template.[13] One of four main ICT policy elements of the template refers to educator competences.

Conclusion

The ubiquity of digital technologies and increasing policy attention on developing student digital competences means that teachers need to be adequately prepared to integrate digital technologies into teaching and learning. Education systems can formalise the development of teacher digital competences through different approaches. These include setting and enforcing professional teacher standards, incentivising professional development, and creating wider support structures for teachers and digital education matters. Various policy levers can help to strengthen the overall effectiveness of each approach, as well as combine to reinforce multiple approaches. For example, professional standards on teacher digital competences can incentivise participation in relevant professional development activities; and wider support structures focused on digital education matters can support the development and monitoring of teacher digital standards, as well as facilitate access to and support for relevant teacher professional development.

Most OECD countries have at least some rules or guidelines about developing teacher digital competences, signalling their importance to teachers and other education stakeholders (e.g. teacher education and teacher training providers) and sometimes enforcing that attention is paid to this topic. However, significant differences exist across countries in terms of how such directives are implemented, and gaps likely exist between the content of teacher digital standards documents and classroom realities. A lack of evaluation and accountability mechanisms, together with unclear expectations on what teacher digital competences are and how they should be developed, may explain these gaps to some extent.

Specific teacher digital standards or competence frameworks can help to provide clear definitions and progression models to guide teacher education and certification processes. Explicitly linking rules and guidelines on developing teacher digital competences to initial teacher education accreditation processes can also ensure that student teachers have relevant opportunities to develop their digital competences as part of their pre-service training, while still affording teacher education providers flexibility and autonomy to define their course content. Education systems could also integrate formal evaluations of teacher digital competences in several ways, including as part of teacher qualification processes (e.g. through competitive/standardised examinations), as an explicit part of teacher trainee evaluations before obtaining fully qualified teacher status, by strengthening the relevance of digital competences in teacher appraisal or external school evaluation criteria, or by creating voluntary or mandatory certification processes.

As digital technology rapidly evolves, incentivising continuous professional development on various aspects of digital education is crucial – especially as it is an area for which there is a high self-reported need amongst teachers across countries (OECD, 2019[2]). Creating strong incentive structures for teachers to engage in developing their digital skills and removing typical barriers to professional development are important goals. These might include new reward and mobility structures within the teaching profession that reflect digital skills, including both vertical (i.e. promotion) and horizontal pathways (e.g. specialised digital roles that come with recognised concessions in teaching responsibilities). Formally recognising digital skills development in other ways, for example through obtaining certification or micro-credentials, can also incentivise motivated teachers to engage in professional development, although such incentives are unlikely to be effective for the wider teacher population unless paired with some formal exemption or fulfilment of professional development obligations that matter for career progression and/or compensation. Facilitating equitable access to relevant professional development content through dedicated platforms, flexible training opportunities (e.g. MOOCs or other hybrid activities) or by providing financial support (e.g. covering training or teacher compensation costs) represent other incentives.

Finally, creating a wider ecosystem approach to supporting the development of student and teacher digital skills can help to coordinate and accelerate digitalisation efforts in a sustainable and equitable way. For example, some countries have created dedicated agencies or teacher knowledge centres that can serve as visible and specialised focal points to coordinate professional development activities and certification processes. These institutions can take charge of implementing whole system initiatives (e.g. curriculum reform, large-scale innovation projects) related to digital education matters. Creating a central body or institution as a focal point for digital education matters may be particularly effective for promoting good practices and equitable access to initiatives in decentralised or federal systems. Other initiatives targeted at the school level, like supporting the use of school digitalisation plans, can also help to engage schools and educators in systematic digitalisation efforts including the development of teacher digital skills.

References

BOA (2022), "Estrategia Aragonesa de Formación en Competencia Digital Docente Ramón y Cajal 2021-2024", *BOA No. 140, 20/07/22*, https://www.cddaragon.es/wp-content/uploads/2022/07/Estrategia-en-BOA.pdf. [25]

BOE (2022), *Resolución de 1 de julio de 2022, de la Dirección General de Evaluación y Cooperación Territorial, por la que se publica el Acuerdo de la Conferencia Sectorial de Educación sobre la certificación, acreditación y reconocimiento de la competencia digital do*, https://www.boe.es/diario_boe/txt.php?id=BOE-A-2022-11574. [24]

BOE (2007), *Orden ECI/3857/2007, de 27 de diciembre, por la que se establecen los requisitos para la verificación de los títulos universitarios oficiales que habiliten para el ejercicio de la profesión de Maestro en Educación Primaria.*, https://www.boe.es/eli/es/o/2007/12/27/eci3857 (accessed on 22 November 2023). [16]

BOE (2007), *Orden ECI/3858/2007, de 27 de diciembre, por la que se establecen los requisitos para la verificación de los títulos universitarios oficiales que habiliten para el ejercicio de las profesiones de Profesor de Educación Secundaria Obligatoria y Bachillerato*, https://www.boe.es/eli/es/o/2007/12/27/eci3858 (accessed on 22 November 2023). [17]

Boeskens, L., D. Nusche and M. Yurita (2020), "Policies to support teachers' continuing professional learning: A conceptual framework and mapping of OECD data", *OECD Education Working Papers*, No. 235, OECD Publishing, Paris, https://doi.org/10.1787/247b7c4d-en. [34]

Brown, D. (2019), *Research and Educator Micro-Credentials*, Digital Promise, https://digitalpromise.org/wp-content/uploads/2019/02/researchandeducatormicrocredentials-v1r2.pdf. [45]

Dellagnelo, L. (2023), "The role of support organisations in implementing digital education policies", in *OECD Digital Education Outlook 2023. Towards an Effective Digital Education Ecosystem*, OECD Publishing, https://doi.org/10.1787/c74f03de-en. [50]

DeMonte, J. (2017), *Micro-credentials for Teachers: What Three Early Adopter States Have Learned So Far*, American Institute for Research, https://openbadges.org/about/. (accessed on 12 October 2020). [46]

European Commission (2013), *Survey of Schools: ICT in Education - Benchmarking Access, Use and Attitudes to Technology in Europe's Schools*, Directorate-General for the Information Society and Media (European Commission), Brussels, https://doi.org/10.2759/94499. [39]

European Commission/EACEA/Eurydice (2019), *Digital Education at School in Europe*, Publications Office of the European Union. [14]

European Commission/EACEA/Eurydice (2015), *Assuring Quality in Education: Policies and Approaches to School Evaluation in Europe*, Publications Office of the European Union, Luxembourg, https://doi.org/10.2797/65355. [29]

Eurydice (2023), "Initial education for teachers working in early childhood and school education", *Ireland*, https://eurydice.eacea.ec.europa.eu/national-education-systems/ireland/initial-education-teachers-working-early-childhood-and-school (accessed on 12 July 2023). [19]

Fraillon, J.; J. Ainley; W. Schulz; T. Friedman; E. Gebhardt (2014), *Preparing for Life in a Digital Age: The IEA International Computer and Information Literacy Study International Report*, Springer International Publishing, Heidelberg, https://research.acer.edu.au/cgi/viewcontent.cgi?article=1009&context=ict_literacy (accessed on 24 January 2020). [36]

Gil-Flores, J., J. Rodríguez-Santero and J. Torres-Gordillo (2017), "Factors that explain the use of ICT in secondary-education classrooms: The role of teacher characteristics and school infrastructure", *Computers in Human Behavior*, Vol. 68, pp. 441-449, https://doi.org/10.1016/j.chb.2016.11.057. [35]

Harris, J., P. Mishra and M. Koehler (2009), "Teachers' technological pedagogical content knowledge and learning activity types: Curriculum-based technology integration refrained", *Journal of Research on Technology in Education*, Vol. 41/4, pp. 393-416, https://doi.org/10.1080/15391523.2009.10782536. [10]

INTEF (2022), *Spanish Framework for the Digital Competence of Teachers*, https://intef.es/wp-content/uploads/2023/04/English-SFDCT_2022.pdf. [15]

ISTE (2017), *ISTE Standards for Educators*, International Standards for Technology in Education, https://www.iste.org/standards/iste-standards-for-teachers. [7]

Koehler, M., P. Mishra and W. Cain (2013), "What is Technological Pedagogical Content Knowledge (TPACK)?", *Journal of Education*, Vol. 193/3, pp. 13-19, https://doi.org/10.1177/002205741319300303. [9]

Minea-Pic, A. (2020), "Innovating teachers' professional learning through digital technologies", *OECD Education Working Papers*, No. 237, OECD Publishing, Paris, https://www.oecd-ilibrary.org/education/innovating-teachers-professional-learning-through-digital-technologies_3329fae9-en (accessed on 24 February 2021). [38]

Ministry of Science and Education (2023), *Rules on the advancement of teachers, professional associates and principals in primary and secondary schools and colleges*, https://www.zakon.hr/cms.htm?id=44746 (accessed on 13 April 2023). [44]

Ministry of Science and Education (2019), *Rulebook on rewarding teachers, teachers, professional associates and principals in primary and secondary schools and student dormitories*, https://narodne-novine.nn.hr/clanci/sluzbeni/2019_05_53_1019.html (accessed on 13 April 2023). [43]

Mishra, P. and M. Koehler (2006), "Technological Pedagogical Content Knowledge: A Framework for Teacher Knowledge", *Teachers College Record*, pp. 1017-1054, https://doi.org/10.1111/j.1467-9620.2006.00684.x. [8]

OECD (2023), *Shaping Digital Education: Enabling Factors for Quality, Equity and Efficiency*, OECD Publishing, Paris, https://doi.org/10.1787/bac4dc9f-en. [28]

OECD (2022), *Assessing National Digital Strategies and their Governance*, OECD Publishing, Paris, https://doi.org/10.1787/baffceca-en. [3]

OECD (2021), *Teachers and Leaders in Vocational Education and Training*, OECD Reviews of Vocational Education and Training, OECD Publishing, Paris, https://doi.org/10.1787/59d4fbb1-en. [31]

OECD (2020), *Education Policy Outlook in Estonia*, OECD Publishing, Paris, https://doi.org/10.1787/9d472195-en. [32]

OECD (2020), *Education Policy Outlook in Germany*, OECD Publishing, Paris, https://doi.org/10.1787/47b795b1-en. [49]

OECD (2020), *Making the Most of Technology for Learning and Training in Latin America*, OECD Skills Studies, OECD Publishing, Paris, https://doi.org/10.1787/ce2b1a62-en. [37]

OECD (2019), *OECD Skills Outlook 2019: Thriving in a Digital World*, OECD Publishing, Paris, https://doi.org/10.1787/df80bc12-en. [12]

OECD (2019), *PISA 2021 ICT Framework*, https://www.oecd.org/pisa/sitedocument/PISA-2021-ICT-Framework.pdf (accessed on 8 April 2022). [40]

OECD (2019), *TALIS 2018 Results (Volume I): Teachers and School Leaders as Lifelong Learners*, TALIS, OECD Publishing, Paris, https://doi.org/10.1787/1d0bc92a-en. [2]

OECD (2019), *Working and Learning Together: Rethinking Human Resource Policies for Schools*, OECD Reviews of School Resources, OECD Publishing, Paris, https://doi.org/10.1787/b7aaf050-en. [41]

OECD (2017), *Education Policy Outlook: Italy*, OECD Publishing, Paris, http://www.oecd.org/education/Education-Policy-Outlook-Country-Profile-Italy.pdf (accessed on 11 May 2022). [48]

OECD (2017), *Survey of Adult Skills*, OECD Publishing, Paris. [47]

OECD (2016), *PISA 2015 Results (Volume II): Policies and Practices for Successful Schools*, OECD Publishing, Paris, https://doi.org/10.1787/888933932760. [33]

OECD (2015), *Education at a Glance 2015: OECD Indicators*, OECD Publishing, Paris, https://doi.org/10.1787/eag-2015-en. [27]

OECD (2015), *Students, Computers and Learning: Making the Connection*, OECD Publishing, Paris, https://doi.org/10.1787/9789264239555-en. [4]

OECD (2013), *Synergies for Better Learning: An International Perspective on Evaluation and Assessment*, OECD Publishing, Paris, https://doi.org/10.1787/9789264190658-en. [26]

Redecker, C. (2017), *European Framework for the Digital Competence of Educators: DigCompEdu*, Publications Office of the European Union, Luxembourg, https://doi.org/10.2760/159770. [5]

Rizza, C. (2011), “ICT and Initial Teacher Education: National Policies”, *OECD Education Working Papers*, No. 61, OECD Publishing, Paris, https://doi.org/10.1787/5kg57kjj5hs8-en. [23]

Scottish Government (2016), *Enhancing learning and teaching through the use of digital technology*, https://www.gov.scot/publications/enhancing-learning-teaching-through-use-digital-technology/documents/ (accessed on 17 November 2023). [30]

Starkey, L. (2020), “A review of research exploring teacher preparation for the digital age”, *Cambridge Journal of Education*, Vol. 50/1, pp. 37-56, https://doi.org/10.1080/0305764X.2019.1625867. [11]

TAR (2018), *Dėl švietimo ir mokslo ministro 2007 m. kovo 29 d. įsakymo Nr. ISAK-555 „Dėl Reikalavimų mokytojų kompiuterinio raštingumo programoms patvirtinimo" pakeitimo*, https://e-seimas.lrs.lt/portal/legalAct/lt/TAD/599d489078af11e89188e16a6495e98c (accessed on 22 November 2023). [18]

The General Teaching Council for Scotland (2019), *Guidelines for Accreditation of Initial Teacher Education Programmes in Scotland*, https://www.gtcs.org.uk/wp-content/uploads/2022/03/ITE-Programme-Accreditation-Guidelines.pdf (accessed on 20 November 2023). [21]

The Teaching Council (2020), *Céim: Standards for Initial Teacher Education*, https://www.teachingcouncil.ie/en/publications/ite-professional-accreditation/ceim-standards-for-initial-teacher-education.pdf (accessed on 12 July 2023). [20]

Tondeur, J.; K. Aesaert; B. Pynoo; J. van Braak; N. Fraeyman; O. Erstad (2017), "Developing a validated instrument to measure preservice teachers' ICT competencies: Meeting the demands of the 21st century", *British Journal of Educational Technology*, Vol. 48/2, https://doi.org/10.1111/bjet.12380. [13]

UNESCO (2018), *UNESCO ICT Competency Framework for Teachers*, United Nations Educational, Scientific and Cultural Organization, Paris, https://unesdoc.unesco.org/ark:/48223/pf0000265721. [6]

Wastiau, P.; R. Blamire; C. Kearney; V. Quittre; E. Van de Gaer; C. Monseur (2013), "The use of ICT in education: A survey of schools in Europe", *European Journal of Education*, Vol. 48/1, pp. 11-27, https://doi.org/10.1111/EJED.12020. [42]

Welsh Government (2018), *Criteria for the accreditation of initial teacher education programmes in Wales*, https://www.gov.wales/sites/default/files/publications/2018-09/criteria-for-the-accreditation-of-initial-teacher-education-programmes-in-wales.pdf (accessed on 20 November 2023). [22]

Yu, J., Q. Vidal and S. Vincent-Lancrin (2023), "Digital teaching and learning resources", in *OECD Digital Education Outlook 2023. Towards an Effective Digital Education Ecosystem*, OECD Publishing, https://doi.org/10.1787/c74f03de-en. [1]

Notes

[1] https://digikomp.at/?id=592

[2] https://innovacionyformacion.educa.madrid.org/competencia-digital#acreditacion

[3] https://www3.gobiernodecanarias.org/medusa/edublog/cprofeslagomera/wp-content/uploads/sites/72/2021/04/plan-plurianual-de-formacion-profesorado-2021-2023.pdf ; https://www3.gobiernodecanarias.org/medusa/perfeccionamiento/areapersonal/tic.php

[4] https://www.juntadeandalucia.es/educacion/portals/web/transformacion-digital-educativa/competencia-digital

[5] Computing is compulsory within the English National Curriculum for Local Authority-maintained schools; other schools in England (e.g. academies or free schools) are not required to follow the English National Curriculum.

[6] https://pld.education.govt.nz/regionally-allocated-pld/pld-priorities/

[7] https://tech.ed.gov/epp/

[8] https://auladelfuturo.intef.es/que-es-el-aula-del-futuro/

[9] https://scuoladigitale.istruzione.it/iniziative-formaz/future-labs/

[10] https://revize.edu.cz/

[11] https://scuoladigitale.istruzione.it/pnsd/

[12] https://technology.tki.org.nz/; https://123tech.nz/; https://www.tepapa.govt.nz/learn/for-educators/raranga-matihiko-weaving-digital-futures; https://www.digitalignition.co.nz/

[13] https://www.vlaanderen.be/kenniscentrum-digisprong/tools/ict-beleidsplanner

Part II Digital Governance

8 Data and technology governance: fostering trust in the use of data

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Data governance encompasses regulation and policies, including the training and resourcing of dedicated staff, to ensure privacy and data protection. After introducing the main concepts and practices of privacy and data protection and laid out societal privacy concerns, the chapter presents a state of the art of countries' regulation and practices. It then examines the sharing of data for education research purposes, another strong benefit of digitalisation beyond personalisation of education. Finally, the chapter reviews a few countries' efforts to provide guidelines about the use of automated decision-making and AI systems and discusses this upcoming area of regulation and governance. The conclusion highlights the importance to keep a risk-management approach when it comes to data and algorithm governance.

Introduction

The development of a digital education ecosystem should enable to use data and digital tools to improve the quality, effectiveness, efficiency and equity of education. A key means lies in the use and reuse of data in real time or so to make better informed decisions or evaluate education practices to design new reforms. One of the risks that needs to be mitigated with this approach relates to privacy and data protection. There is in most societies a low level of trust in the use and reuse of data and legitimate discomfort with the possibility of privacy breaches. For that purpose, most countries have enacted robust privacy and data protection laws and policies that cover the handling and sharing of data within education systems.

It is important to distinguish between different types of data to reflect on data governance. Statistical data have long been collected and have their laws and processes. They are generally made available to the public and will not be discussed as such in this chapter. The chapter mainly focuses on two types of data: administrative data, which are collected in the process of delivering education or education programmes; and to a lesser extent, commercial data, notably those which are collected by commercial vendors while students or teachers use educational software in school (or for school).

The digital transformation has also raised awareness about smart technologies that can either make automated decisions or support educators. The emergence of generative artificial intelligence (AI) has made the power of AI visible to all. At the same time, some observers worry that algorithms may be biased and even amplify human biases, even though they also have the potential to limit the interference of human biases in educational decisions. Even though the use of automated systems is very rare in education (and public automated decision-making inexistent), a few countries are in the process of setting new expectations about automated decision-making and AI systems, either through guidelines regarding algorithms and AI or through regulation. The “Opportunities, guidelines and guardrails” presented in this report (OECD, 2023[1]) deal with guidelines around the use of generative AI in education.

The first section introduces the main concepts and practices of privacy and data protection, lays out societal privacy concerns and highlights the need to balance the risks of re-identification of individuals against the value of the collected or shared data. The second section presents a state of the art of countries’ privacy and data protection regulation, how they regulate data protection and privacy through tiered-access policies and sometimes through technology. Sharing data with researchers should be a key dimension of countries’ data governance, which may also consider establishing data spaces leveraging the (process) data that are collected by commercial vendors. Finally, the penultimate section reviews a few country efforts to provide guidelines about the use of automated decision-making and AI systems as an upcoming area of regulation. The conclusion highlights the importance to keep a risk-management approach when it comes to data and algorithm governance.

Privacy and data protection: an introduction

The data collected by digital administrative tools often contain personal information that identifies students and teachers, either directly or indirectly, and some datasets collected by commercial digital education tools and solutions do as well. A big question of data protection in education is about privacy (and ultimately safety and well-being), and how to balance it with the use and reuse of data within the digital education ecosystem and with research and innovation utilisations which involve sharing de-identified data with third parties.

Personal information

The concept of personal information is central to modern privacy law. The standard legal approach is that some data elements represent personal information – that is, they make it possible to identify individuals –

while others do not. Generally, only personal information falls within the scope of privacy legislation. The distinction between personal and non-personal information is thus the basis for assigning rights and responsibilities to individuals ("data subjects") and to the entities ("data custodians" or "data controllers") collecting and managing data records about these individuals.

From a traditional legal standpoint, therefore, privacy risks appear largely confined to those data elements that are considered personal information. Naturally, context plays a role and any given data element may be considered personal or not depending on whether the circumstances and other available information allow a reasonable inference about the identities of the individuals included in the dataset.

The distinction between personal and non-personal data is a standard feature of privacy frameworks across the OECD area. The *OECD Guidelines Governing the Protection of Privacy and Transborder Flows of Personal Data* define "personal data" as "any information relating to an identified or identifiable individual (data subject)". The notion of personal data is also paramount to the EU General Data Protection Regulation (GDPR) that came into force in May 2018 replacing and extending the 1995 EU Data Protection Directive (Directive 95/46/EC). Article 4 of the GDPR defines "personal data" as:

> *"any information relating to an identified or identifiable natural person ('data subject'); […] one who can be identified, directly or indirectly, in particular by reference to an identifier such as a name, an identification number, location data, an online identifier or to one or more factors specific to the physical, physiological, genetic, mental, economic, cultural or social identity of that natural person".*

In the United States, personal data is referred to with the term "personally identifiable information" (PII). Under the US Family Educational and Privacy Rights Act (FERPA), which sets legal requirements to protect the privacy of education records, PII includes, but is not limited to:

> *"(a) The student's name; (b) The name of the student's parent or other family members; (c) The address of the student or student's family; (d) A personal identifier, such as the student's Social Security Number, student number, or biometric record; (e) Other indirect identifiers, such as the student's date of birth, place of birth, and mother's maiden name; (f) Other information that, alone or in combination, is linked or linkable to a specific student that would allow a reasonable person in the school community, who does not have personal knowledge of the relevant circumstances, to identify the student with reasonable certainty; (g) Information requested by a person who the educational agency or institution reasonably believes knows the identity of the student to whom the education record relates" (34 CFR § 99.3).*

A basic tenet of privacy regulation is that the protection of natural persons applies to the *processing* of their personal data, that is, to the operations performed on these data, such as collection, storage, structuring, adaptation, analysis or dissemination. The *OECD Privacy Guidelines* apply specifically to personal data and establish eight guiding principles for data collection and data use to be respectful of personal privacy (Box 8.1). While originally formulated in 1980, the revision of the guidelines in 2013 reconfirmed the principles as relevant in "an open, interconnected environment in which personal data is increasingly a valuable asset" and where "more extensive and innovative uses of personal data bring greater economic and social benefits, but also increase privacy risks" (OECD, 2013[2]).

It is important to underline that legal frameworks such as the GDPR and FERPA do not prohibit the exchange or processing of personal data but, instead, lay restrictions on it and establish that a legal basis (such as national law) is necessary for specific processing situations. Among those, data use in the public interest, including for scientific, research or statistical purposes, often merit a set of special provisions (e.g. Article 89 of GDPR).

Box 8.1. Guiding principles for the protection of privacy in the use of personal data

The OECD Guidelines Governing the Protection of Privacy and Transborder Flows of Personal Data represent an international consensus on privacy standards and provide guidance on the collection and use of personal information in any medium. The policy principles for the protection of privacy and individual liberties established by the guidelines can be supplemented by additional measures at the national level. The guidelines outline eight principles for the collection and use of personal data:

1. **Collection limitation principle**. There should be limits to the collection of personal data and any such data should be obtained by lawful and fair means and, where appropriate, with the knowledge or consent of the data subject.
2. **Data quality principle**. Personal data should be relevant to the purposes for which they are to be used, and, to the extent necessary for those purposes, should be accurate, complete and kept up-to-date.
3. **Purpose specification principle**. The purposes for which personal data are collected should be specified not later than at the time of data collection and the subsequent use limited to the fulfilment of those purposes or such others as are not incompatible with those purposes and as are specified on each occasion of change of purpose.
4. **Use limitation principle**. Personal data should not be disclosed, made available or otherwise used for purposes other than those specified in accordance with the preceding principle except a) with the consent of the data subject; or b) by the authority of law.
5. **Security safeguards principle**. Personal data should be protected by reasonable security safeguards against such risks as loss or unauthorised access, destruction, use, modification or disclosure of data.
6. **Openness principle**. There should be a general policy of openness about developments, practices and policies with respect to personal data. Means should be readily available of establishing the existence and nature of personal data, and the main purposes of their use, as well as the identity and usual residence of the data controller.
7. **Individual participation principle**. Individuals should have the right: a) to obtain from a data controller, or otherwise, confirmation of whether or not the data controller has data relating to them; b) to have communicated to them, data relating to them […]; c) to be given reasons if a request made under subparagraphs (a) and (b) is denied, and to be able to challenge such denial; and d) to challenge data relating to them and, if the challenge is successful to have the data erased, rectified, completed or amended.
8. **Accountability principle**. A data controller should be accountable for complying with measures which give effect to the principles stated above.

Source: (OECD, 2013[3])

Personal data can be generated in many ways with varying degrees of individual involvement and awareness of the data generation process (Abrams, 2014[4]). First, personal data may be provided or revealed by choice, as through surveys; they can also be revealed though compulsory disclosure, as when set as a pre-condition to receiving services, as in the case of school registration. Second, they may be created without full consent or awareness from the data subject, as in the form of data traces from online tracking or sensor observation (e.g. (Buckley et al., 2021[5])). In addition, personal data can increasingly be derived or inferred from other existing data, either mechanically or by probabilistic means. In the context of administrative collections, data subjects normally retain visibility and control over the information that concerns them. More and more, however, individuals also create and share, either consciously or inadvertently, personal information about themselves and others (e.g. schoolmates, teachers) in platforms such as social networks, photo-sharing sites or rating systems. These platforms are often part of larger application ecosystems that can access personal data from multiple online services (e.g. contact lists through mobile phone applications), making it possible not only to combine users' information but also to infer "shadow profiles" of non-users, which highlights the collective aspects of privacy in the new digital environments (García et al., 2018[6]).

Legal definitions reflect these complexities by underscoring that personal data may either identify individuals in a forthwith manner, or enable their identification through other, less straightforward means. This relates to the standard distinction between "direct" and "indirect" (or "quasi") identifiers, both of which fall under the broader concept of personal data.

Direct identifiers are data elements that provide an explicit link to a data subject and can readily identify an individual. For students and their families, examples of direct identifiers include names, addresses, social security or other administrative numbers or codes, unique education-based identification numbers or codes, photographs, fingerprints, or other biometric records. Other forms of data generated digitally within or outside educational settings can also apply. For instance, under the EU GDPR, data elements such as an email address, location data from mobile phones or an Internet Protocol (IP) address can also be considered personal data. For teachers and other school staff, most of the same variables can serve as direct identifiers, as well as other data elements such as teaching assignments or scores on professional evaluations.

In turn, indirect or quasi-identifiers are data elements that, despite not being unique to a particular data subject, may still be used to identify particular individuals, normally in combination with other available information. Examples of indirect student identifiers include postal codes or other location information, gender, racial or ethnic identity, date and place of birth, grade level, course enrolment, participation in specific educational programmes, or information about transfers between schools or institutions. For teachers, quasi-identifiers can also include marital status, income, information on credentials, certification and training, tenure status or teaching assignments, among others.

There is a grey area around the identifiability potential of other types of education data. For instance, data about school menus or about textbooks and other learning materials assigned to students in particular courses may not contain any personal information. However, combined with other data elements, such information may serve to identify individual students or educators.

Moreover, when the possibility of linking student and teacher records exist, student-level information may easily become an indirect identifier for an individual teacher, and vice versa. This is particularly important for longitudinal information systems that maintain information on both students and educators; for such systems, any detailed inventory of personal data elements requiring privacy protection should include elements relating to both categories of data subjects and potential linkages between them (NCES, 2011[7]).

The conceptual distinction between personal and non-personal data informs the idea that suppressing personal information from a given dataset is an effective strategy to eliminate privacy risks. Within this view, privacy protection takes aim at the data elements themselves and relies chiefly on the de-identification of individual-level personal records. However, the notion of a meaningful divide between personal and non-personal information based on their 'identifiability' potential is increasingly put into question.

The blurring distinction between personal and non-personal information

A growing consensus exists among privacy experts that advances in data availability and analytics bring about a gigantic leap in the capacity to relate seemingly non-personal data to identified or identifiable individuals in a variety of contexts, thereby multiplying opportunities for (re-)identifying data subjects (for an overview, (National Academies of Sciences, 2017[8]). This possibility challenges regulatory approaches that establish privacy rights and restrictions to data use based on the distinction between personal and non-personal information.

Some examples illustrate how developments in data collection and analytics have transformed the playing field by increasing the capacity to infer sensitive information from seemingly safe data. In a famous study, (Sweeney, 1997[9]) was able to identify the medical records of a state governor in the United States by matching information on date of birth, postal code and gender found in publicly released voter registration records and medical encounter data.[1] Researchers also managed to re-identify Netflix subscribers by matching their rating records and reviews on the Internet Movie Database (IMDb) based on movie titles and release dates (Narayanan and Shmatikov, 2008[10]). Another example is the use, by retail company Target, of historical purchase data to infer the likelihood that female customers were in early stages of a pregnancy and subsequently adapt marketing offers (Duhigg, 2012[11]). Analyses of credit card transactions and location-temporal data for more than 1 million individuals have also shown that only four data points may be needed to uniquely identify about 90% of the data subjects within these large datasets (de Montjoye et al., 2015[12]) (de Montjoye et al., 2013[13]). Rocher, Hendrickx and de Montjoye (2019[14]) review further examples of successful re-identification in purportedly anonymous datasets and present a statistical model to quantify the likelihood of success of a re-identification attempt on heavily incomplete datasets. These examples show how, despite the application of thorough de-identification and sampling procedures, re-identification remains possible in high-dimensional datasets that provide information on a large number of attributes per individual. Moreover, inferences about sensitive personal traits and about the presence of records from a given individual are also possible through attacks on aggregate data (for a review, (Dwork et al., 2017[15]).

These developments yield a growing sense of unease about the capacity of traditional privacy protection approaches in the era of Big Data. As put by the President's Council of Advisors on Science and Technology in the United States,

> *"Anonymization is increasingly easily defeated by the very techniques that are being developed for many legitimate applications of big data. In general, as the size and diversity of available data grows, the likelihood of being able to re-identify individuals (that is, re-associate their records with their names) grows substantially. While anonymization may remain somewhat useful as an added safeguard in some situations, approaches that deem it, by itself, a sufficient safeguard need updating" (Executive Office of the President, 2014, p. xi[16]).*

Administrative education data are not exempt from these perils. A student or teacher may appear in an external dataset that contains some uniquely identifying information that has been removed from duly anonymised education records. However, if the two data sources can be matched on some other shared or overlapping variables, then the matching brings the possibility of identifying the student or teacher in the education dataset as well as of expanding the amount of information available about them. For example, a student's school records may be linked to data from a university financial aid service, or to responses to a survey on labour market outcomes. The student's social security number may appear in the latter sources only, but birth dates may be present in all sources. Through the linkage, the school records could then be attributed to particular social security number holders. In the same vein, the student's academic record could be linked to health or crime data collected by other public agencies using any shared data elements.

In this example, uncertainty may exist about the identity of students sharing the same birth date. However, auxiliary information from additional shared variables (e.g. gender, postal codes) could also be brought in to establish the matching of pairs of students born on the same day between the different datasets. Overlapping elements that univocally identify individuals allow direct and exact matching, also known as deterministic record linkage; by contrast, when uncertainty remains about the uniqueness of the data records, the matching is still possible through probabilistic record linkage techniques.

Additionally, re-identification of a student or teacher may occur through the combination of education data records with information from other types of sources, such as events reported in the media. For instance, a student's school records may reveal that disciplinary action was taken for involvement in a bullying incident, without further specifying the identity of other students involved or the presumed motivations of the event. However, local media reports of the incident, even without revealing the names of the students, may contain additional information about the event. The date of the incident or the reported age of the students could then be used by someone with access to both sources to re-identify the involved students.

While linkages to external sources may provide opportunities for re-identification, it is important to note that identity attribution can also occur through the combination of data elements within a given education dataset, or by inferring the identity of an individual in a given category from aggregated published statistics. These instances are of particular relevance for students and teachers in population sub-groups represented in low numbers in a given context. For instance, a demographic breakdown of the results of students from a given school or municipality in a public examination may be combined with information on grade levels, gender and ethnicity to identify individual students with a set of observable characteristics and specific academic outcomes.

These examples show how the relative prevalence of indirect personal identifiers is positively associated to the likelihood of re-identification. Highly uncommon personal characteristics of students or teachers can more easily lead to disclosing their individual identities than traits more widely shared in the population. A student's special education status, a teacher's unusual certifications or, more generally, postal codes of residents in sparsely populated areas are examples of variables that can be highly informative about individual identities within a given dataset.

Re-identification risks are also dynamic and cumulative. In the case of administrative education data, risk can be associated, most importantly, to prior releases of other education records as well as to the information available through other sources. Generally, as the amount and diversity of data grow, possibilities for re-identifying students and teachers using their education records increase exponentially.

Responding to privacy concerns

Fears that personal data may be accessed without authorisation or used inappropriately have become acute and widespread in recent years. This provides the backdrop for the concern that the release of education records, even when duly anonymised, poses risks for students and teachers.

Cyber-security

Inadequate protection against cyber-attacks in an extended concern, as these may lead to a data breach and a disclosure of personal information. There is evidence that such incidents have increased in scale and profile in recent years. According to a survey commissioned by the UK government, 46% of businesses in the country identified at least one cyber security attack in 2016, with the incidence rising to 68% among large firms (UK Department for Digital, Culture, Media & Sport, 2017). Government agencies have also suffered large data breaches: examples include the theft of more than 21 million records from the US Office of Personnel Management in 2015, a leak at the Japanese Pension Service affecting more than 1 million people in 2015, and the loss of a portable hard drive containing personal information about almost 600 000 student loan recipients in Canada in 2012 (OECD, 2016[17]); (Office of the Privacy Commissioner of Canada, 2015[18]). Overall, the scale of data breaches, including for government records, has been growing over the last decade (Information is Beautiful, 2019[19]). However, while this type of events contribute to the perception of a low level of data security in digital environments, research on the frequency of cybercrime suggests that actual risks are often over-estimated. Despite the proliferation of cyber-attacks, once their frequency is expressed as a proportion of the number and size of Internet-related activities, the evidence points to an improvement rather a deterioration of online security (Jardine, 2015[20]). The same could probably be said as a proportion of the amount of available digital data.

Data misuse concerns

Inappropriate use of personal data is also a widespread worry. In the European Union, about half (46%) of respondents to a 2019 Eurobarometer on cyber-security expressed concerns about someone misusing their personal data (European Commission, 2019[21]). In the United States, in 2023, 34% of respondents surveyed by the Pew Research Centre reported they had been the target of some form of data break or hacking in the past year. They also expressed mistrust in the use of their personal data by the government (71% were "very" or "somewhat" concerned about how the government uses these data) and by companies (67% said they understand little to nothing about what companies do with their personal data) (Pew Research Center, 2023[22]). A previous 2019 survey found that most felt that the potential risks of those data collections outweighed the benefits (81% for data collected by companies and 66% for data collected by the government) (Pew Research Center, 2019[23]).

In education, concerns that data may be used inappropriately, especially for commercial purposes, often stem from the increasing involvement of private technology companies in the operations of schools and universities. The sharing of administrative student and teacher data with technology vendors is often required to enable service provision for educational organisations, from administration (e.g. scheduling) to digital learning (e.g. instructional software and content, data dashboards) or testing (e.g. computer-based assessments). Local education authorities and schools often lack the time and technical expertise required to manage their expanding databases, and have thus to rely on third-party operators offering cloud-based computing and other online solutions. Even when privacy laws place third parties under the same obligations regarding privacy safeguards as these organisations, letting private companies manage personal education data remains a controversial topic (Polonetski and Jerome, 2014[24]).

The growing involvement of technology providers in schools is well illustrated by the case of Google. More than 20 million Google-powered Chromebook laptops have been deployed in schools globally since their launch in 2011 while, as of January 2021, the company subscribed 150 million students and teachers worldwide to its G Suite for Education (introduced in 2010 as Google Apps for Education), up from 70 million in 2017.[2] The suite provides solutions for emailing, document management and networking, and is complemented by education-specific applications such as the virtual reality Google Expeditions tool. In the United States, the company pledges full compliance with FERPA and other privacy protection regulations which prohibit school service providers from utilising student information for targeted advertising. In line with these requirements, ads are turned off when users in primary and secondary schools are signed in to their G Suite accounts.[3] However, concerns remain about tracking and targeted advertising when users transition to applications external to the suite, amid broader claims that the presence of technology companies in schools increasingly exposes children to targeted marketing and other commercial practices (Boninger and Molnar, 2016[25]) (Singer, 2017[26]).

Similarly, there are concerns about the ability of providers of virtual learning environments and Massive Open Online Courses (MOOCs) to eschew the student privacy protections that prevail in school and university settings by collecting data directly from learners, often under a privacy regime that applies instead to general commercial transactions (Zeide and Nissenbaum, 2018[27]).

Behaviour-monitoring and biometric data

A related worry is that the introduction of behaviour-monitoring and biometric identification technologies expands the typology of personal data collected in schools. In the United States, this has led a growing number of jurisdictions to introduce new legislation targeting industry and extending privacy safeguards to data other than traditional administrative student records. The Student Online Personal Information Protection Act (SOPIPA) passed in California in September 2014 was the first to put responsibility for protecting student data directly on industry by expressly prohibiting technology service providers from selling student data or creating student profiles for non-educational purposes. SOPIPA has since served as a model for the introduction of similar legislation in other states (Singer, 2014[28]) (Data Quality

Campaign, 2017[29]). More generally, the Children's Online Privacy Protection Act (COPPA) of 1998 prohibits the collection, use and dissemination of personal information from children under the age of 13 without informed, advance parental consent.

In the European Union, the GDPR and the revised Audiovisual Media Services Directive (AVMSD) include special provisions for the protection of minors' personal data, particularly to prevent data processing for commercial purposes such as direct marketing, profiling and behaviourally-targeted advertising (Ronchi and Robinson, 2019[30]). Regulations of commercial uses of personal education data have tightened with the framework of the GDPR: under the new rules, digital service providers are considered data 'processors' while students and schools remain data 'controllers' and retain legal control over their data and decision power over third-party data requests (Articles 4-6, 35).[4]

Potential harms from privacy breaches

A privacy breach can expose students and teachers to different types of harms, most worryingly to discriminatory practices. Harms resulting from a privacy breach can be objective or subjective, and involve economic, legal, psycho-emotional or reputational dimensions.[5] The potential to cause harm is commonly used as a major criterion in determining the sensitivity of a data element and the need of applying privacy controls. However, delineating the legitimate boundaries for (harmless) information disclosure is often difficult as some uses of data that may risk to invade privacy can also have a social value (Solove, 2006[31]).

In addition to commercial marketing, potential harms that may arise from the misuse of student and teacher personal information include profiling and discrimination, identity theft, or emotional distress. For schools and universities with responsibilities in managing personal records, confidentiality breaches could bring reputational costs, the burden of investigating and remediating incidents, and associated financial losses.

The risk of profiling is of special relevance given the comprehensive and longitudinal nature of some administrative education datasets. Profiling refers to the use of data with the purpose of analysing personal characteristics or behavioural patterns, placing an individual or group of individuals in categories (profiles) and making predictions about their capacities, preferences or behaviours. Combined with automated decision-making, there is a risk that it enables machines to make decisions without human involvement and based on profiles derived from personal data (EU Data Protection Working Party, 2017[32]) (Future of Privacy Forum, 2017[33]) (Information Commissioner's Office, 2017[34]). In fact, this is typically how AI in education operates, usually under the supervision of human beings (OECD, 2021[35]).

The key concern about profiling is that, based on these predictions, vulnerable individuals and communities suffer differential treatment or discrimination in practices such as access to social services and benefits, educational opportunities, hiring or insurance, among others. For example, denial of opportunity for students in certain ability categories, higher termination rates for benefit eligibility based on prior receipt of scholarships, of filtering of job candidates by type of institution attended rather than academic records. These could add to other forms of unfair treatment by gender, race or other personal characteristics. Student records starting from early schooling and spanning over multiple years could be used, alone or in combination with data from other sources, to create student profiles that condition decisions and opportunities in an unfair manner at later stages of their educational trajectories and beyond. This is notwithstanding the fact that education records are routinely and legitimately used for decisions such as admissions to post-secondary education institutions or the granting of financial aid. This concern is encapsulated in the concept of "algorithmic bias" (Baker, Hawn and Lee, 2023[36]).

A related concern is the visibility and permanence of records that signal a "negative" event in the trajectory of a student, which could in turn lead to denial of opportunity. This could for instance occur if a student's disciplinary behavioural records are used to assess the student's suitability for a job later on. These dilemmas are similar to those posed by potential uses of health or juvenile court records. Another potential harm is that expectations about the accessibility of personal information lead to perverse incentives or reinforce risk-aversion in high-stakes situations. For example, students could be discouraged to enrol in some tertiary-level courses if they suspect that prospective employers will use curricular choices as an indicator of certain personal preferences (e.g. political views, sexual orientation) and filter job applicants on that basis. Teachers, in turn, may be less inclined to try out innovative practices of more uncertain outcomes than business-as-usual teaching if they fear that a lack of positive results may affect their job mobility or promotion prospects. These concerns are more an ethical issue related to human beings misusing information that they did not have in the past.

At the core of these problem lies the fact that having more data is no guarantee of better inferences and fairer decisions. A selective and arbitrary use of the education records available – especially as these become more granular and cover more time points and more aspects of individuals' traits and behaviours – can lead to biased decision-making and discriminatory practices. Greater data availability opens the doors to harms *if data are used inappropriately*, but higher quality data and certain profiling applications can also serve to fight discrimination as well as to personalise and improve services (EU Data Protection Working Party, 2017[32]) (Future of Privacy Forum, 2017[33]).

Rather than a ban on or over-protective approach to the use of personal records because of their possible risks, the question remains how to use them according to criteria that are valued and considered fair in society. Another challenge that data protection policies must address is to create individual and societal trust in the use of data and invent ways to address concerns that people have, whether their concerns are supported by evidence or not.

Data protection and privacy across countries

All countries and jurisdictions for which we have information but the United States have a general, cross-sectoral law about privacy and data protection, which applies to education as well as all other sectors of society. All members of the European Union and some neighbouring countries (e.g. the United Kingdom and Norway) follow the EU GDPR, which must be implemented in all EU countries. The United States has a different approach: rather than a general law, it has a series of sectoral privacy and data protection laws, including one for education (FERPA). All these general laws are national. In terms of content, they are also all based on the data protection principles presented in the previous section.

About half of the countries/jurisdictions also have an additional education law (or binding rule) about privacy and data protection related to education data and settings (13 out of 28). Usually, the law clarifies countries' access to the data they collect and handle in their student information systems (EMIS) and other administrative systems. The rules embed access restrictions rules to the systems, and also how the data can be shared, used, etc. Countries with no central student information system (or that have a small education system) tend not to have an additional regulation. Most of the guidelines issued by central authorities provide information to support schools and teacher to properly apply various country regulations about privacy and data protection.

In Europe, a few countries follow the GDPR only (e.g. Czechia, where the government collects aggregated student information only). Most countries have transposed the GDPR in their national laws, which remain general and apply to education. This is for example the case in England (*Data Protection Act 2018* and *UK GDPR*), Finland (*Data Protection Act)*, Iceland (*2018 Act on Data Protection and the Processing of Personal Data)* or Ireland *(Data Protection Act 2018).*

Under the general framework of the GDPR, some countries have also developed specific education rules – and usually a more restrictive approach than what the GDPR imposes. For instance, Sweden translated the GDPR into its Education Act. In France, the Education Code (*Code de l'éducation)* covers the data privacy of students, teachers, and staff, restricting the use of data and prescribing anonymisation rules for their information. Given France's active digital education policy, officials within the ministry of education work in close collaboration with the National Commission for Information Technology and Liberties (*Commission Nationale de l'Informatique et des Libertés* - CNIL) to discuss new educational use cases.

In Austria, the Education Documentation Act (BilDokG – *Bildungsdokumentationsgesetz*) ensures data privacy at all educational levels for students, teachers, and staff. The law regulates data governance, from data collection stages to usage. For instance, when data is transferred from schools to statistical organisations, the information must be anonymised and the student identifier pseudonymised. Data usage beyond research or statistical purposes is forbidden. In addition, the 2021 ICT School Ordinance (*IKT-Schulverordnung*) regulates the use of digital devices used in schools, for example mandating the installation of a government-owned device management software in all publicly distributed digital devices. To prevent possible misuse of data from third-party digital service providers outside of Austria, digital service providers must have a contract with the government that ensures the usage of collected data is limited to pedagogical purposes.

A few European countries allow or require schools or municipalities to set their own additional privacy rules (in compliance with their national laws and the GDPR). For example, Italian schools are asked to have data privacy rules which are monitored by external data protection officers. Dutch schools appoint data protection officers to set privacy policies and raise awareness among school staff on data privacy. In Spain, while the Organic Law 3/2018 transposed the GDPR in Spain's national law and specifically addressed data protection in education, further rules or guidelines to specific uses of technologies apply in autonomous regional governments depending on their educational context. The national government provides guidelines on data privacy and protection through its *AsequraTIC* website though.

Outside of Europe, countries also have laws that are sometimes inspired by or aligned with the EU GDPR. In Brazil, the Personal Data Protection General Law (LGPD) shows several parallel to the GDPR, even though the LGPD has a stricter definition of personal data. Türkiye's Personal Data Protection Law (KVKK) was inspired by the GDPR, and Türkiye has no specific rules or guidelines about education. Finally, while Chile has had a data protection law for decades, a law project covering general data protection and privacy based on the GDPR was being discussed as of early 2024.

In Canada, two main documents ensure the general protection of data and privacy. The Freedom of Information and Protection of Privacy Act (FIPPA) guarantees individual right to access to own information, while the Personal Information Protection and Electronic Documents Act (PIPEDA) requires individual consent to collection, disclosure, and usage of personal information. Specific data protection laws on education are the responsibility of different provinces and territories. For instance, New Brunswick's Right to Information and Protection of Privacy Act specifically addresses data protection rules and guidelines in education, such as guidelines and restriction measures to commercial vendors regarding their use of student or staff data that schools should confirm before signing procurement contracts.

In Japan, the *Act on the Protection of Personal Information* (APPI) governs the handling of personal information (including education data when it constitutes personal information). Until 2022, the APPI regulated only the personal information held by the private sector, while the personal information held by government bodies and incorporated administrative agencies were rules by the *Act on the Protection of Personal Information Held by Administrative Organs* (APPIHAO) and the *Act on the Protection of Personal Information Held by Incorporated Administrative Agenci*es (APPIHIAA). An amendment in May 2021 has integrated those two acts into the APPI and stipulated a mandatory reporting of data leakage while placing more severe penalties for the non-compliance of PPC's orders. Since 2023, the APPI also covers the handling of personal information held at the subgovernment level.

The United States has taken a sectoral approach to data protection. Education is one of the sectors with a data protection law: the *Family Educational Rights and Privacy Act* (FERPA), mentioned above. It is supplemented by the Protection of Pupil Rights Amendment (PPRA), the *Children's Internet Protection Act* (CIPA), and the *Children's Online Privacy Protection Rule* (COPPA) that regulate different aspects of data protection and privacy. Because they concern children, the two latter laws also concern education. States have the autonomy to set up their own general or specific laws or rules about data protection and privacy above and beyond the federal ones. The federal department of education publishes guidelines for schools and other stakeholders explaining how to comply with the data protection measures. Other specific guidelines and/or laws on data collection in digital tools and protection measures are under the responsibility of US states. For example, California has a cross-cutting data protection act and specific state guidance on data protection.

In sum, all countries have well-developed privacy and data protection regulations, which typically comes with some guidelines on how to implement their data protection law, even though those guidelines may remain general and not focused on a school-level implementation.

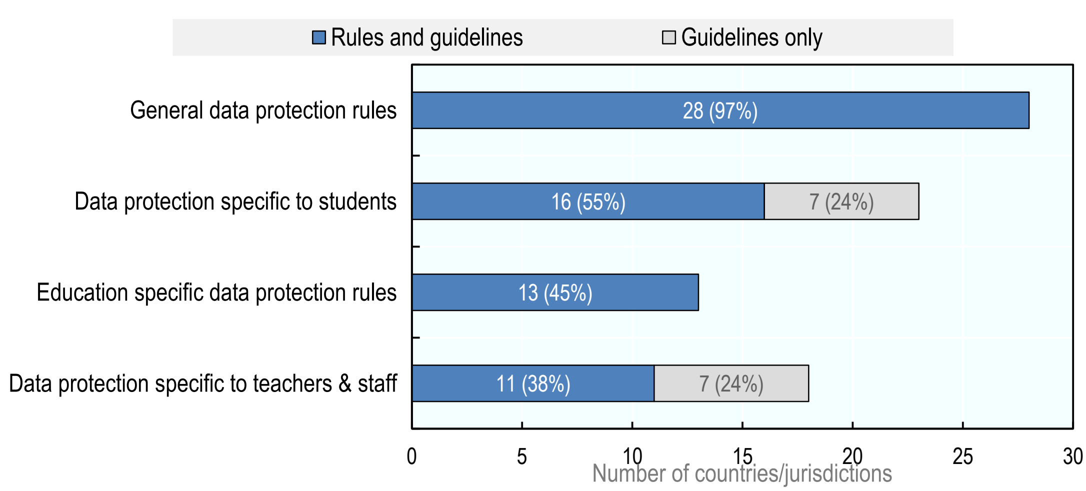
Student and staff protection regimes

Under countries' data protection law, some aspects of students' and education staff' privacy and data are protected. An alternative to a general law could have been to have specific privacy and data protection for students and/or for education staff. Those two questions were asked in the OECD data collection (and validation meetings with countries). When it comes to the statistical/research sharing of their data to third parties, students and school staff (mainly teachers) are covered by similar regulation.

However, because some students are children, they usually also benefit from additional regulations that do not apply to school staff. Some countries have also specific, separate laws about handling the data of minors/children (e.g. the United states), which apply to children in school. About 24 (out of 29) countries/jurisdictions report rules (17) or guidelines (7) on the protection of data and privacy specifically of student data, above and beyond their general data protection and privacy regime.

This is less often the case for school staff and teachers, with 12 countries reporting specific data protection regulation and 6 to have guidelines. While the handling of data of staff and students is typically the same, they are typically in a different position because the use of their data by their employers depends on their employment contracts (and countries' employment laws) rather than broad regimes of data protection laws. In the Nordic countries, where municipalities hire teachers, this is left to local employment contracts and collective bargaining. In the United States, for example, this would be addressed by the federal employment law and employment contracts.

Figure 8.1. Data protection rules and guidelines across countries and jurisdictions (2024)



Note: N=29.

StatLink https://stat.link/0wug47

Table 8.1. Types of data protection rules and guidelines (2024)

	Data protection						
	General data protection rules		Education specific data protection rules	Data protection specific to students		Data protection specific to teachers & staff	
	Rules and guidelines	Guidelines only	Rules	Rules and guidelines	Guidelines only	Rules and guidelines	Guidelines only
Austria	✓		✓	✓		✓	
Brazil	✓						
Canada	✓		✓	✓		✓	
Chile	✓			✓			
Czechia	✓						
Denmark	✓		✓		✓	✓	
Estonia	✓			✓			
Finland	✓		✓		✓		✓
France	✓		✓	✓		✓	
Hungary	✓		✓	✓		✓	
Iceland	✓						
Ireland	✓			✓		✓	
Italy	✓				✓		
Japan	✓		✓		✓		✓
Korea	✓			✓			✓
Latvia	✓			✓			
Lithuania	✓			✓		✓	
Luxembourg	✓		✓			✓	
Mexico	✓				✓		✓
Netherlands	✓						✓
New Zealand	✓		✓	✓			
Slovenia	✓			✓		✓	
Spain	✓		✓		✓		✓
Sweden	✓			✓			
Türkiye	✓		✓				
United States			✓	✓			
England (United Kingdom)	✓				✓		✓
Flemish Comm. (Belgium)	✓		✓	✓		✓	
French Comm. (Belgium)	✓			✓		✓	
Total (29)	**28**	**0**	**13**	**16**	**7**	**11**	**7**

Note: N=29.

Regulating privacy by tiered-access policies

As mentioned for student information systems, many countries use a tiered model for accessing the data they collect, which establishes a clear differentiation of access rights both among data custodians and among external parties based on their roles, needs and responsibilities. By clarifying who should have access to what types of data and for what purposes, a tiered model can inform the design of an information system and help it embed privacy and data security principles. Role-based access models align with principle of data minimisation recognised in modern privacy legal frameworks such as the GDPR. For instance, in Article 25, the regulation calls for controllers to hold and process only the data absolutely necessary for the completion of their duties, as well as for limiting the access to personal data to those needing to carry out the processing. Many education systems publicise the few people who have access to all data.

Within an education agency, a role-based access model means that identifiable student and teacher records within an information system will only be accessible to personnel who need that information to support their professional roles. Job descriptions should detail the rights of each type of user and specify with enough granularity the tasks requiring access to personal records. Staff may be asked to sign obligations binding them to protect data confidentiality before being granted access to sensitive data.

Role-based access models can be used to organise points of entry into an information system for different stakeholders in the education system, as well as reporting and data visualisations functionalities. For example, the work of an elementary school teacher can benefit from timely access to recent student data on attendance, grades and performance on various assessments, but not require access to detailed information on medical histories or school transfers for all students in the school. In turn, the administrator of a policy program targeting students with a specific profile, such as non-native speakers, can arguably better organise placements into such programmes when having access to past education records and identifying information on students' family backgrounds. Meanwhile, an analyst in a public agency's research or evaluation unit who is responsible for generating aggregated reports of student performance and submit them to higher-level authorities would need access to the performance results but not the direct identifiers for individual students. Therefore, rather than allowing each employee or external user access to all electronic student records or restricting access to needed elements one user at a time, managers of education information systems can grant access to a set of data elements based on role differentiation (NCES, 2011[7]).

Most countries use this tiered access approach for their administrative data systems such as student information systems or admission management systems. Importantly, all privacy and data protection laws presented above prevent schools or educational agencies from sharing personal data or outcomes for other purposes than school and educational operations. (One exception for data sharing includes access for research, which is elaborated below.)

Regulating access through technology

Increasingly digitalised learning environments call for new solutions to ensure privacy-respectful and lawful uses of student and teacher personal data. Increasingly, technology is used to ensure this is the case as part of technical "interoperability" layers that limit the personal information that is shared with third (and notably commercial) parties.

For example, since 2020 the Netherlands has introduced a new student identifier (different from their national identifier) and data exchange layer that schools use to prevent commercial vendors to know their personal identity: the ECK iD. The Flemish Community of Belgium has a similar approach. Another approach is the *Gestionnaire d'Accès aux Ressources* (GAR) developed by the French Ministry of Education, which acts as a security filter ensuring that the data exchanges between schools and providers of digital learning resources comply with the proportionality and relevance principles recognised by national and EU privacy regulations (Box 8.2). The solution also establishes contractual agreements and technical and legal standards requiring, for instance, that resource providers refrain from reusing personal data for commercial purposes and enable data subjects to easily retrieve their data.

Box 8.2. Protecting personal data in virtual learning environments: France's *Gestionnaire d'Accès aux Ressources* (GAR)

Within the framework of the 2015 Digital Plan for Schools (*Plan Numérique à l'École*), the French Ministry of Education has developed the *Gestionnaire d'Accès aux Ressources* (GAR), a technical solution to guarantee the protection of student and teacher personal data while using virtual learning environments (VLE) in schools. GAR acts as a security filter ensuring that data exchanges between schools and providers of digital educational resources necessary for letting students and teachers access these resources comply with the proportionality and relevance principles recognised by the French Law on Information Technology and Personal Liberties (*Loi Informatique et Libertés*) and the EU General Data Protection Regulation (GDPR).

In France, school principals are responsible for selecting the digital resources to which their schools subscribe. Students and teachers access these resources through VLEs, which often involves that user information needs to be transmitted from schools to publishers or other commercial resource providers. The GAR system centralises and simplifies several aspects of this process. Firstly, it provides a single interface that groups and makes accessible all active subscriptions for students and teachers. Secondly, it provides a secure channel for data exchange by anonymising identifiers and minimising the amount of data transmitted. This relies on an upstream evaluation by ministry staff of whether the personal data requested by a resource provider is proportional and relevant to the use of a particular resource. GAR operates as an invisible filter for users of VLEs, but educators can identify secure resources thanks to a "Compatible GAR" that accompanies resource descriptions and that is issued by the Ministry to providers adhering to the system. For resource providers, GAR also provides a unique distribution point to give visibility to their materials.

GAR is compatible with the whole range of learning resources, including reference materials, multimedia, digital textbooks and tools for designing new materials. In addition to each school's subscriptions, the Ministry of Education offers all schools in France free access to two large banks of resources that are gradually being integrated in GAR: *Éduthèque*, with pedagogical materials developed by large public institutions, and the *BRNE* repository of resources from private publishers that covers core disciplinary subjects at primary and secondary levels of education. Overall, the system provides a trusted framework for privacy-respectful data exchanges that can support further uses of digital technologies in the school context.

A pilot version of GAR was first deployed in September 2017 in 82 schools and 10 VLEs. By June 2018, the solution was deployed in more than 300 schools across France and enabled almost 4 000 resource access requests per day. As of 2023, the system was deployed in the entire country.

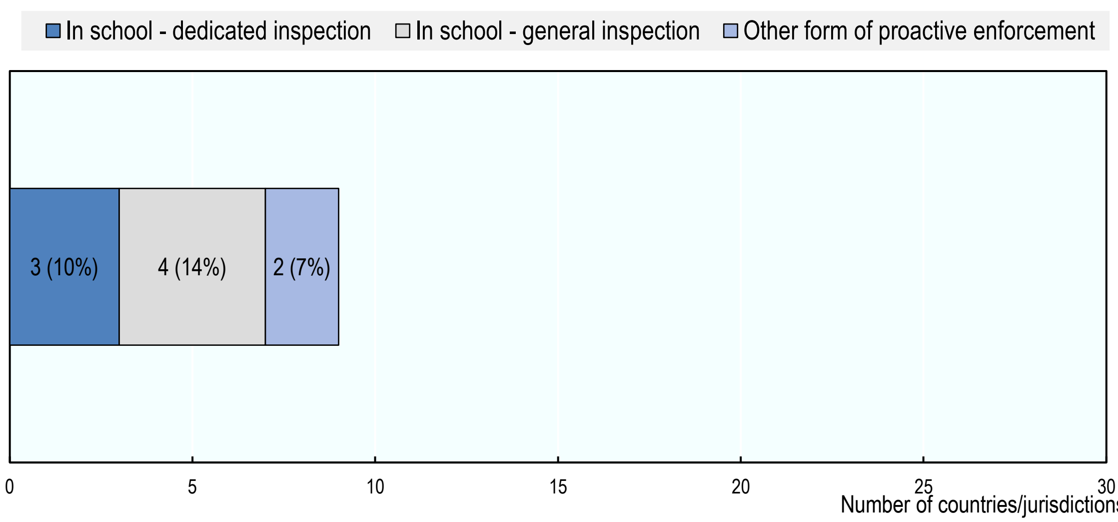
Source: (Commission Nationale de l'Informatique et des Libertés, 2017[37]) Ministère de l'Éducation Nationale website (https://gar.education.fr/);

Enhancing data sharing through empowering schools and staff

While tiered access policies and technological solutions alleviate the burden of the implementation of data protection for school staff, providing appropriate guidance to teachers, school leaders and families is another important action point. Most countries have these types of strategies, and provide at least some level of guidance. Providing guidance and making communication efforts to reach school staff and teachers is different though. Regulation and policies are not always well-known or understood. In many cases, law gets clarified because of court decisions and can remain ambiguous before then. This may lead education stakeholders to either implement either an over- or under-protective approach to privacy and data protection. One way to develop a trustworthy culture in the use of data and digital technology would be to have more institutional support on these matters. This is usually the case at the governmental level, for the use of digital administrative tools, but less often the case at the school level. Some countries expect school inspections to cover this dimension alongside all other ones.

A few countries have a specific workforce to support schools and verify the implementation of their data (and digital technology) policies. Austria includes trained staff on IT and data protection issues in its school inspections. Italy mandates that schools have an external data protection officer. The national data protection agency and other services of the ministry in France have a pro-active approach to verify how data and digital tools are used in school. Moreover, while the inspectors may or may not get specific training on this and focus on many other aspects, regular school inspections cover data protection in a few countries (Flemish Community of Belgium, Chile, Ireland, and New Zealand) (Figure 8.2).

Figure 8.2. Number of countries/jurisdictions with a proactive approach to data and digital technology policy enforcement (2024)



Note: Austria, France and Italy have dedicated IT enforcement. The Flemish Community of Belgium, Chile, Ireland and New Zealand cover data protection as part of their general inspections. The French Community of Belgium has proactive verification and enforcement at its central level. The United States also reported proactive mechanisms designed by law for its data protection policies to be enforced. N=29.

StatLink https://stat.link/rvewpa

Sharing and access to data for research and system learning

While enhancing the real-time use of the data generated by countries' digital ecosystem to inform decisions should be an objective, a strong digital education ecosystem also generates data that countries can use for research, evaluation and learning. For this purpose, the collected data should be made available to researchers under strong privacy rules.

Access to administrative data for research

Data have long been collected in education for statistical purposes. The digitalisation of data collected by different institutions as part of their operations has multiplied the quantity and quality of relevant data that can be used for research and improvement purposes. In particular, the emergence of new generations of longitudinal student information systems that collect records about individuals over a number of years, and sometimes from kindergarten to the workforce, have opened unprecedented research opportunities (Figlio, Karbownik and Salvanes, 2016[38]; Dynarski and Berends, 2015[39]). Increasingly, different data sources can be linked to offer a better understanding of the determinants and effects of contextual factors on educational outcomes, or, conversely, of educational trajectories on other outcomes (income, health, employment, etc.).

Administrative data refer to data collected by governments and other public entities as part of their operations (delivery or law enforcement). They typically belong to two categories (Office of Management and Budget (United States), 2016[40]):

- Large-scale administrative data typically cover a very large share of (or the entire) population concerned by a programme. They can be cross-sectional or longitudinal. In education, longitudinal information systems following each student at the school level are a good example. Large scale administrative data can also be collected about teachers and others.
- Programme-specific administrative data typically cover the recipients of a programme as part of the delivery of this programme. This may for example be the case for student grants and other programmes targeted to a sub-population of students, for example involved in a government programme.

Administrative data differ from survey data in that they are not primarily collected for research purposes – and often, by having a coverage that cannot be matched by a survey. While some administrative data are collected for statistical purposes, most of them are not. What digitalisation allows is to use the potential of this data for research, assuming researchers can analyse them. There are several differences between survey and administrative data: an important one is that the research survey principle of “notice and consent” is largely not appropriate for administrative data.

Countries typically use both a data-focused and governance-focused controls to make administrative data accessible to researchers. These solutions are fully complementary within a broader privacy protection strategy.

Data-focused controls consist in treating data prior to their release or sharing. They reduce privacy risks by transforming data, for example by removing or obscuring the association between the data subjects and the data elements. This involves a range of data de-identification techniques, including suppression, blurring, perturbation, randomisation or sub-sampling. These techniques target formal identifiers but also include ways to distort information and to prevent statistical linkages. Despite their limitations, the de-identification of sensitive data prior to their release remains an essential component of the privacy protection toolkit (Cavoukian and El Emam, 2011[41]). De-identified administrative datasets are indeed safely used in many countries for research and evaluation purposes in education, health and other fields. Even if records are de-identified[6] prior to the release or sharing of a dataset, the risk of re-identifying[7] individuals or disclosing sensitive information about them may persist as data collections proliferate within and outside educational settings and as new analytic techniques increase opportunities to mine, link and draw inferences from data.

Governance-focused solutions, in turn, seek to restrain the interactions that custodians and users have with the data, both by regulating the conditions for data access and use and by increasing their awareness and capacity to address privacy risks. Data governance can help protect privacy by establishing effective controls and procedures in at least four areas: physical and IT data security; tiered access models; supervised access and licensing solutions; and privacy awareness, training and communication. A good governance model implements actions in all four areas and operates in combination with data-focused solutions.

Most countries share at least some of their administrative data under usual statistical data sharing laws – and often use different data-governance techniques that make it very difficult to re-identify individuals. As noted above, most data protection and privacy laws have a "research exception" that allows for the sharing of de-identified data collected by public agencies with researchers – under certain conditions.

Countries report different modes of access for researchers though.

21 (out of 29) give access to (at least some of) their administrative under the same conditions (rather than ad hoc application processes) to all researchers. In some cases, these conditions can be restrictive: for example, in Washington state (United States), researchers can only access data if data have not already been provided to other researchers to explore similar research questions. In many cases, the difficulties to share are due to a lack of human resources (and budget). While most countries give a similar access to public and private researchers, a few countries only give access to public researchers (Chile, French Community of Belgium and Türkiye).

The documentation of administrative datasets is a key aspect to equal access to education researchers is to diverse administrative datasets. Documenting a dataset mainly lies in having a public dictionary of the data available in a dataset. When not documented, given that administrative systems are typically not open to the public, even if they can apply for access to the data, researchers will typically not know what research questions they could answer by using the dataset, unless they know people who maintain or use the systems. While the documentation of datasets is a burdensome exercise that requires human resources and budget, it is key for the use of administrative data by researchers. Slightly less than half of the countries for which we have information (13 out of 29) document all or most of their administrative education datasets. In countries that do not document their administrative datasets, there cannot truly be a fair and equal research access to data.

Access to data collected by commercial tools and solutions

In the past, most data collected within schools were only accessible to schools and government agencies. Because they now use a variety of digital tools and resources that are proprietary, some companies have access to student data. Access and use of those data is regulated by privacy and data protection laws, usually with special requirements for the data of minors. One common prohibition is for vendors to use these data for marketing and commercial purposes.

However, the use of specific digital tools and resources in schools (or for school education), for example adaptive learning tools, also generates data that commercial vendors can use. Increasingly, technical solutions are put in place that prevent or limit the possibilities of private companies to know the identity of their users. However, the use of those data allow them to improve their algorithms and services. These data are typically the property of vendors.

One question for countries is whether some of the data collected by commercial vendors within (public) schools should be available either for research or for the development of new education products. For example, should the use of adaptive learning systems in public schools (hypothetically) have the potential to allow for a breakthrough in the understanding of how to support the learning of students, for example by making them follow certain learning sequences, it might be beneficial for education systems to make some of the data collected by commercial vendors accessible to researchers and even other companies. In many sectors, the sharing of data and the establishment of "data spaces" made of data collected by companies and reused by other organisations is an aspiration. This is for example what the EU Data Governance Act that was passed in 2022 and became applicable since September 2023 attempts to promote, with measures trying to increase trust in data sharing, for example by allowing data intermediaries and facilitating the reuse of public data.[8]

In Austria, in principle no data can leave schools, so that neither the commercial providers of the digital tools/resources nor anyone else should be able to access and reuse data that were collected in schools, including process data. It is the only country that reported a rule on accessing or sharing data collected by commercial vendors.

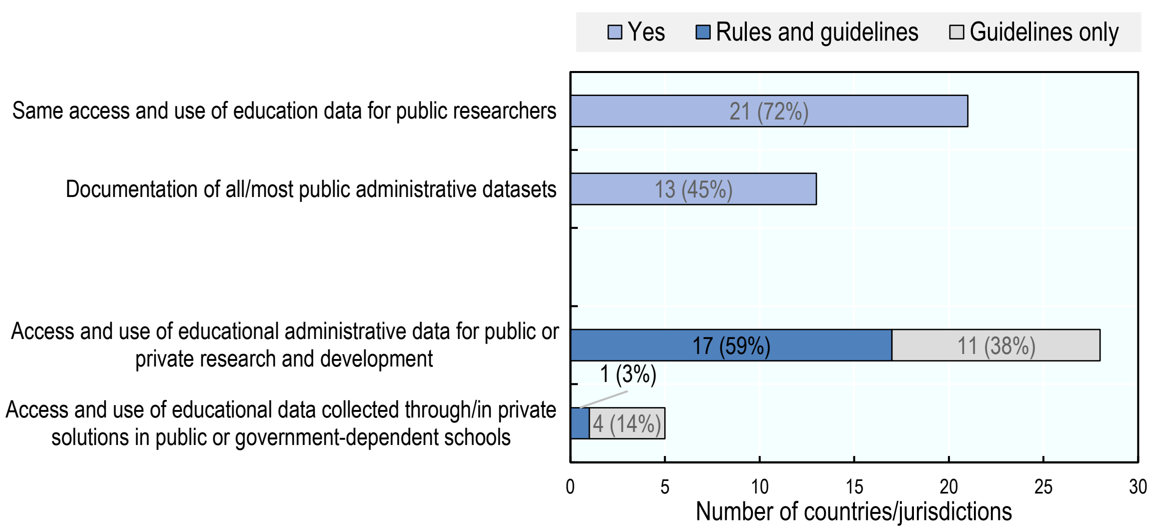
The interviews with government officials highlighted the lack of mechanisms and awareness about the possible benefits of reusing some of the data collected by business providers – a measure that would have to balance incentives for commercial developers and societal benefits.

Summary

To conclude, a key aspect of countries' data governance should be a consideration about giving a wide access to their administrative data to researchers, with respect to privacy regulation, and under equitable conditions. Fairness in access to all researchers requires the public documentation of their datasets. Governments should also consider to what extent they should develop incentives for commercial vendors to share some of the data they collect in the context of public education – not so much the data about students, but the use and process data that could help researchers or other vendors to improve teaching and learning.

Figure 8.3 and provide a summary of the main access policies within countries as of early 2024.

Figure 8.3. Access to data for public and private researchers (2024)



Note: N=29.

StatLink https://stat.link/cp6mh0

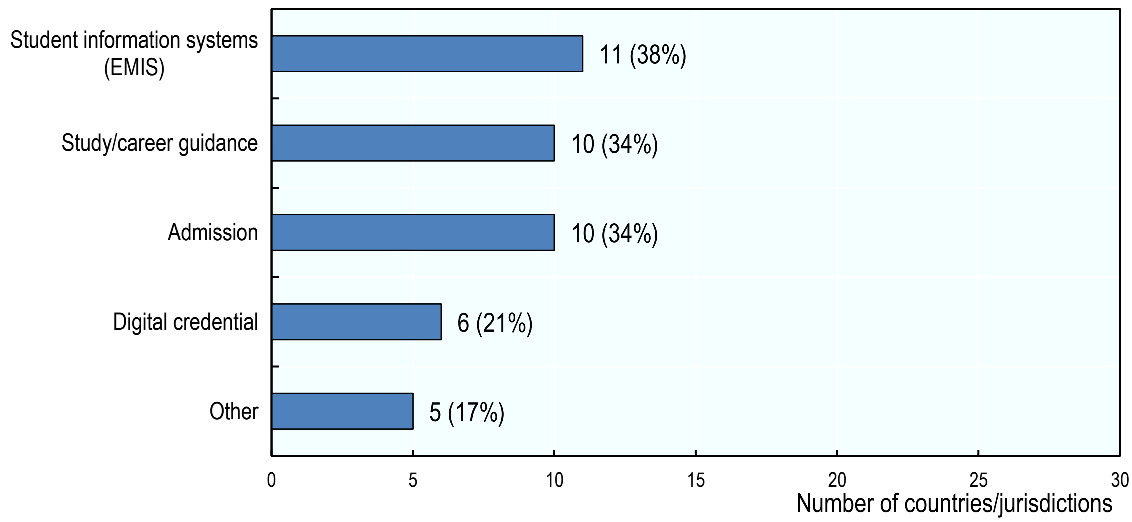
Table 8.2. Access to public and private educational data (2024)

	Documentation of all/most public administrative datasets	Same access and use of education data for public researchers	Access and use of educational administrative data for public or private research and development		Access and use of educational data collected through/in private solutions in public or government-dependent schools	
			Rules	Guidelines	Rules	Guidelines
Austria		✓	✓		✓	
Brazil	✓	✓	✓			
Canada						
Chile	✓	✓				
Czechia						
Denmark	✓	✓	✓	✓		
Estonia	✓	✓	✓			
Finland	✓	✓	✓	✓		
France		✓	✓			
Hungary		✓	✓			
Iceland						
Ireland	✓					
Italy		✓	✓	✓		
Japan						
Korea	✓	✓	✓	✓		
Latvia	✓	✓	✓			✓
Lithuania	✓	✓	✓	✓		
Luxembourg						
Mexico		✓		✓		✓
Netherlands		✓	✓	✓		
New Zealand	✓	✓	✓			
Slovenia						
Spain						
Sweden		✓	✓	✓		
Türkiye	✓	✓				
United States	✓	✓	✓	✓		
England (United Kingdom)	✓	✓	✓	✓		
Flemish Comm. (Belgium)		✓	✓	✓		✓
French Comm. (Belgium)		✓				✓
Total	**13**	**21**	**17**	**11**	**1**	**4**

Regulation about algorithms, AI systems and automated decision-making

While data governance mainly focuses on the handling and sharing of data, new concerns have emerged about the governance of technology itself, and notably algorithms that support automated decision-making (and AI algorithms). OECD countries and Brazil do not have many automated decision-making systems in their education systems in terms of management tools, if any. There are a few rule-based algorithms used for making some decisions or allocations, but countries usually note that the algorithms only inform rather than make the decision. Figure 8.4 presents the extent to which rule-based algorithms are used by different categories of systems provided by governments (acknowledging that no AI-based systems were available yet). Regarding AI algorithms, the question was understood as the use of algorithms that allow to detect, diagnose or act on different educational aspects. Sometimes, the use of those advanced rule-based algorithms is just about casting light on some aspects of the data (detecting issues through dashboards) or to make sure that credentials are verifiable.

Figure 8.4. Countries and jurisdictions with advanced rule-based algorithms (dashboards, rule-based decisions, etc.) (2024)



Note: N=29

StatLink https://stat.link/3vd2pi

There may be more sophisticated systems in schools and classrooms, for example adaptive learning systems (including intelligent tutoring systems) and, here and there, some of the advanced uses of AI in the classroom presented in the *Digital Education Outlook 2021* (Baker, 2021[42]; OECD, 2021[35]; D'Mello, 2021[43]; Dillenbourg, 2021[44]) which predate the public emergence and use of generative AI (OECD, 2023[45]).

While AI in education presents many opportunities, there are also several possible risks.

One challenge is that the technology may not be as effective as one would wish: the models ay not perform very well what they are designed to do. In many cases, this does not matter as it may still be helpful and do no harm; it may also still perform better than human beings. For some types of decisions, for example those that are high stakes for individuals, tolerating error is not acceptable though (even though this should be compared to human error for a similar task). One possible consideration for guidance or regulation would thus be around the effectiveness of technology solutions. Countries could consider asking education technology developers to disclose the level of effectiveness of their tools – verify it themselves, or get it verified by accredited third parties. Whether this is worth doing depends on the risk posed by error.

A second challenge is that technology may increase inequity or fairness, two issues that are antithetic with educational objectives. The worsening of inequity may come from the fact that some algorithms, for example those used for adaptive learning work better for some students than others – and contribute to increasing the gap between those groups rather than decreasing it. In some cases, this may come from algorithmic bias, which occurs when an algorithm encodes (typically unintentionally) the biases present in society, producing predictions or inferences that do either not perform the same way for all groups of a population or are clearly discriminatory towards specific groups (Baker, Hawn and Lee, 2023[36]). Countries should thus consider measures to identify whether these types of biases are present when they use digital technology and address them.

Other challenges are ethical and relate to human rights and dignity and to democratic values. In 2019, the OECD has adopted a Recommendation on Artificial Intelligence that promote "use of AI that is innovative and trustworthy and that respects human rights and democratic values" and provide principles on how governments and other actors can "shape a human-centric approach to trustworthy AI" (OECD, 2019[46])[9]. UNESCO has adopted a global *Recommendation on the Ethics of Artificial Intelligence* in 2021 (UNESCO, 2021[47]).

First examples of guidance or governance of technology

This section presents some guidelines and rules that are emerging across countries. Regulation has the advantage of being enforced but could stifle innovation and prevent technological innovation where the regulation applies. Guidelines have the advantage to give directions and shape expected behaviours: they allow for a societal dialogue and to explore different uses of technology, but they have the disadvantage of being non-binding and thus leave some serious issues to ethics.

As of 2024, France is the only country that already implements some binding rules in this area. These rules apply to algorithms provided by public agencies and schools. France's digital law requires that algorithms (used by public agencies) be explainable to lay people and open source. Within schools, part of the restrictions come from the ministry of education. For example, AI cannot be used for behavioural studies, but only for pedagogical purposes. AI systems about engagement based on gamification can be used, but systems with eye-tracking functionalities are for example only allowed for research purposes (see (D'Mello, 2021[43]) for a review of these AI systems). Overall, high-stakes highly automated systems are forbidden.

As part of its digital strategy, the European Union plans to regulate artificial intelligence (AI) to facilitate its development and use: the Artificial Intelligence Act should be passed early 2024. The Act proposal adopts a risk-based approach and requires a series of disclosures and assessments for AI developers. Similar to medical devices, it proposes to have authorisations for AI software to be put on the market. To support innovation, it will also provide temporary exemptions for the testing of AI (Box 8.3). These "regulatory sandboxes" appear as a promising way to develop AI systems (OECD, 2023[48]). Should the Act be adopted as planned, a careful definition of the forbidden systems will need to be given. The proposed risk-management approach seems to apply by sectors in the negotiating position – with education included as a "high-risk" area.

Box 8.3. The negotiating position on an EU Artificial Intelligence Act: education as a "high-risk" area

In June 2023, after a framework proposal by the European Commission, the European Parliament adopted a "negotiating position" on the AI Act, a first step towards the adoption of the law. Its stated objective is that AI systems used in the European Union are "safe, transparent, traceable, non-discriminatory and environmentally friendly" and that they "should be overseen by people, rather than by automation, to prevent harmful outcomes".

The law is cross-sectoral and classifies AI systems according to the perceived risks they entail, with corresponding levels of regulation, going from a ban to minimal regulation.

The following types of systems are planned to be prohibited and classified as having "unacceptable risks":

- Cognitive behavioural manipulation of people or specific vulnerable groups;
- Social scoring: classifying people based on behaviour, socio-economic status or personal characteristics;
- Real-time and remote biometric identification systems, such as facial recognition;

A second category of authorised, "high-risk" systems would have to be assessed before being put on the market and throughout their life-cycle. AI systems in the area of "education and vocational training" belong to this category, alongside 7 other areas as well as all products already under the EU product safety legislation.

General-purpose AI such as generative AI would have to disclose that content was generated by AI and publish summaries of copyrighted data used for training. Their model should only be prevented from generating illegal content.

Limited risk systems include those that generate or manipulate image, audio or video content. They will have some transparency requirements (e.g. the acknowledgment that there are some AI applications) and companies developing these systems will be encouraged to follow the same regulation as the "high-risk" systems.

The EU AI Office would monitor the implementation of the EU AI rulebook.

To allow for European innovation, some exemptions for research activities and for AI components provided under open-source licenses are foreseen. Regulatory sandboxes (allowing for some exemptions from GDPR for a testing period) as well as real-life environments established by public authorities to test AI before it is deployed would be authorised and even encouraged.

Source: See text (European Parliament, 2021[49]) (https://www.europarl.europa.eu/doceo/document/TA-9-2023-0236_EN.html) and press releases (https://www.europarl.europa.eu/news/en/press-room/20230609IPR96212/meps-ready-to-negotiate-first-ever-rules-for-safe-and-transparent-ai).

The United States has also released a blueprint for legislation about AI systems that is meant to inform government regulation as well as organisational practices. It focuses on the effectiveness of algorithms, that is, making sure that they do what they are supposed to do; the prevention of bias against some groups; people's agency on their data handling; disclosure that an algorithm is being used; and the option of human support when a problem arises (Box 8.4).

Box 8.4. US Blueprint for an AI Bill of Rights and educational recommendations on AI

The US Blueprint for an AI Bill of Rights is a set of five principles and associated practices developed by the Office of Science and Technology Policy (OSTP) at the White House through extensive consultation with the US public. It aims to help guide the design, use, and deployment of automated systems in the age of artificial intelligence. It supplements existing law to provide guidance to relevant organisations, from governments at all levels to companies of all sizes. The framework provides a values statement and toolkit across all sectors to protect civil rights, civil liberties and privacy according to democratic values to inform policy, practice, or the technological design process.

The five principles are as follows:

1. You should be protected from unsafe or ineffective systems.
2. You should not face discrimination by algorithms and systems should be used and designed in an equitable way.
3. You should be protected from abusive data practices via built-in protections and you should have agency over how data about you is used
4. You should know that an automated system is being used and understand how and why it contributes to outcomes that impact you.
5. You should be able to opt out, where appropriate, and have access to a person who can quickly consider and remedy problems you encounter.

The Office of Technology of the US Department of Education released in May 2023 a report on AI and the future of teaching and learning that makes 7 related recommendations: 1) Emphasise humans in the loop; 2) Align AI models to a shared vision of education; 3) Design using modern learning principles; 4) Prioritize strengthening trust; 5) Inform and involve educators; 6) Focus R&D on addressing context and enhancing trust and safety; 7) Develop education-specific guidelines and guardrails.

Source: (Office of Education Technology (OET), 2023[50]; White House Office of Science and Technology Policy (WHOSTP), 2022[51]).

Korea has issues “ethical principles” on the use of AI that play the same role (Box 8.5). And New Zealand has developed a charter for its government agencies that also follow similar standards on a voluntary basis: explain algorithms, disclose how data are secured, engage with stakeholders, identify and manage possible bias and keep a “human in the loop” (Box 8.6).

Box 8.5. Korea's Ethical Principles for Artificial Intelligence in Education (2022)

As part of its objective to embrace "Artificial intelligence that supports human growth," the Korean government set 10 specific goals and guidelines to support the ethical use of artificial intelligence in education:

1.Support the potential of human growth.

- In the field of education, artificial intelligence should be provided respecting human dignity and in order to bring out the potential for human growth.

2. Ensure learners' initiative and diversity.

- Respect the individuality and diversity of learners while enhancing their self-directedness.

3. Respect the expertise of educators.

- Respect the expertise of educators and use AI to develop/utilise effectively their expertise.

4. Maintain strong relationships among educational stakeholders.

- Provide support in forming positive relationships among those involved in the education process throughout a series of teaching and learning activities.

5. Guarantee equal opportunities and fairness in education.

- Ensure fair access to education for all members of society, regardless of their regional or economic backgrounds.

6. Strengthen solidarity and cooperation in the educational community.

- Promote collaboration between government, private sector, academia, and research institutions in the use of AI in education and work towards creating a sustainable educational digital ecosystem.

7. Contribute to enhancing social values.

- Equip learners with the qualities of responsible citizens, positively impacting their personal happiness and the common good of society.

8. Ensure the safety of educational stakeholders.

- Implement AI tools in a way that prevents potential risks that may arise in a series of teaching and learning processes, ensuring safety, and clearly defining responsible parties in the use of AI.

9. Ensure transparency and explainability in data processing.

- Ensure transparency in data collection, cleaning, selection, and make algorithm and data processing procedures explainable in a language understandable by educational stakeholders.

10. Use data for legitimate purposes and protect privacy.

- Collect data for the development and utilisation of AI in education to an extent appropriate for the intended purposes, aligned with educational goals, and protect individuals' personal information and private areas during data processing.

Source: SAFE USE OF AI IN EDUCATION (moe.go.kr).

Box 8.6. Algorithm charter for Aotearoa New Zealand

New Zealand has developed in 2020 an algorithm charter as part of a broader data protection ecosystem. The Guidelines propose a framework to carefully manage how algorithms are used by government agencies to strike the right balance between privacy and transparency and prevent unintended bias. Alongside 25 other government agencies, as of November 2023 the charter was endorsed by the Ministry of Education, the Education Review Office, the Tertiary Education Commission as well as the Oranga Tamariki – Ministry for Children. The commitments of the signatories of the charter are as follows:

1. *Transparency*. Maintain transparency by clearly explaining how decisions are informed by algorithms. This may include:
    - plain English documentation of the algorithm;
    - making information about the data and processes available (unless a lawful restriction prevents this);
    - publishing information about how data are collected, secured and stored.
2. *Partnership*. Deliver clear public benefit through Treaty |of Waitangi] commitments by:
    - embedding a Te Ao Māori perspective in the development and use of algorithms consistent with the principles of the Treaty of Waitangi.
3. *People*. Focus on people by:
    - identifying and actively engaging with people, communities and groups who have an interest in algorithms, and consulting with those impacted by their use.
4. *Data*. Make sure data is fit for purpose by:
    - understanding its limitations;
    - identifying and managing bias.
5. *Privacy, ethics, and human rights*. Ensure that privacy, ethics and human rights are safeguarded by:
    - regularly peer reviewing algorithms to assess for unintended consequences and act on this information.
6. *Human oversight*. Retain human oversight by:
    - nominating a point of contact for public inquiries about algorithms
    - providing a channel for challenging or appealing of decisions informed by algorithms
    - clearly explaining the role of humans in decisions informed by algorithms.

Source: https://data.govt.nz/toolkit/data-ethics/government-algorithm-transparency-and-accountability/ and https://data.govt.nz/assets/data-ethics/algorithm/Algorithm-Charter-2020_Final-English-1.pdf

Conclusions and policy pointers

This chapter highlights that countries tend to have robust privacy and data protection policies. All have privacy and data protection regulations in place, and in many cases education-specific ones. A few countries make schools responsible for the implementation of their data protection, and while most do not proactively verify the implementation of the law, they limit the possibilities of privacy breaches in many different ways. Most take a tiered-access policies to their digital tools, thus limiting access to personal data. Some make it mandatory for schools to have a data protection officer (Italy) or make data protection a dimension of their school inspections (Ireland). Increasingly technology itself is a way to protect privacy, with the use of technology layers that manage students' and teachers' identity and prevent third parties to identify people using their digital platforms.

Most countries also de-identify and make (some of their) administrative datasets available for research. While there is a risk of re-identification, there is unprecedented value in analysing these data for system improvement and innovation. While most countries provide some level of access to their datasets, they should also document them to allow for a wider use by their research community.

Privacy protection should be compatible with the use of data for educational improvement and innovation

Education systems need to find privacy-protective models of education data use that can support educational research and improvements in teaching and learning in order to raise performance and reduce achievement gaps. In the status quo, the use of administrative data for system-level monitoring and evaluation poses little problems with regard to privacy or data security. However, the innovation frontier calls for highly granular and timely information to inform education policy and practice, which often implies a greater reliance on individual-level, personal data and greater privacy risks.

The challenge for education agencies is to balance privacy and data security requirements with opportunities for improving research and for shaping teaching and learning practices. With the appropriate safeguards, education stakeholders should be able to access and use administrative data for legitimate purposes and in a timely manner. The benefits of such uses of data, currently overshadowed by privacy risks, should also become more visible.

The way forward is a risk-management approach

Education systems can adopt a risk-management approach to address the policy tensions between privacy and other important objectives. A risk-management approach recognises a diversity of uses of personal education records, their potential benefits, and their associated privacy risks, and serves to reconcile legitimate privacy concerns of students, families and educators with the use of education data to improve educational outcomes. Governments across the OECD are increasingly adopting risk-management approaches in the context of digital security (OECD, 2016[17]), as called for in the *OECD Revised Guidelines on the Protection of Privacy and Transborder Flows of Personal Data* (OECD, 2013[2]) and the *OECD Digital Security Risk Recommendation for Economic and Social Prosperity* (OECD, 2015[52]).

A first step in this direction is to break away with the expectation of fully eliminating risk in the use of education data. Unless one entirely disregards the analytical value of data, scenarios with zero privacy risk are unrealistic. Reducing the granularity of information to protect confidentiality most often implies diminished accuracy and utility of data. Managing risk means accepting that there will be a residual privacy risk in any useful data release, and also evaluating and adopting the most suitable privacy protection measures in light of the intended data uses and potential threats. Another requirement is to shift the focus from privacy controls at the stages of data collection and transformation, to controls on data access, sharing and use (Elliot et al., 2016[53]; Altman et al., 2015[54]).

A wide range of strategies and tools exist to support the implementation of a privacy risks management approach. Many of these privacy protection strategies are already applied in other sectors where public agencies engage in extensive data sharing for research and evaluation purposes, most notably in health (OECD, 2013[55]; OECD, 2015[56]). The portfolio includes *data-focused solutions (i.e. treating data prior to* *their release or sharing*) as well as *governance solutions (i.e. controls on data access and data use)*. Effective privacy protection requires applying both types of strategies in conjunction.

While more recent, the governance of algorithms underlying digital education tools and resources is increasingly important as education systems get mode digitised. Here again, a risk-management approach should be adopted. The main risks with algorithms lie in algorithmic bias that perform or produce different outcomes for different population groups. Baker (2023[36]) highlights the existing research on algorithmic bias and highlights the need for countries to balance privacy and data protection against possible algorithmic bias, acknowledging that bias can only be identified and addressed if personal (and sometimes even sensitive) data are collected.

A second risk lies in the effectiveness of smart technologies, notably when making automated decisions or making high stake recommendations to humans. While algorithms can have the advantage of systematically applying some rules, human beings should still oversee them – and effectiveness should be demonstrated when decisions are high stakes for individuals.

A third risk relates to social acceptance and public trust. Explaining and publicising how smart technology works, how it handles data, engaging with education stakeholders to explain how their work are examples of approaches to addressing this issue. Being transparent about how algorithms work (explainability) and about the values and criteria it uses in its implementation is getting increasingly important.

Those are the pillars of most existing guidelines and principles in this area, including the OECD Opportunities, guidelines and guardrails about the effective and equitable use of AI in education (see (OECD, 2023[1]).

In which cases technology per se would require regulation and along what lines is one of the areas that international discussions can inform. Countries have other possible policies to address these issues and ensure appropriate digital tools are available to their education stakeholders. For example, countries could embed in their procurement procedures some requirements on the performance or fairness of digital tools.

Law and regulation should come with support for school staff

Privacy and data protection as well as policies regarding the use of digital tools and resources represent mounting responsibilities for school leaders and school staff. Beyond regulation, most countries should provide schools with guidelines explaining the law, and provide use cases and examples. Most countries take a reactive approach and wait to respond to complaints and privacy breaches. Providing a mix of proactive verifications, not necessarily to sanction but to develop people's capacity in the field, would be a way to create more trust in how school handle data, and less fear about using digital tools and resources.

While privacy and data protection is an imperative, it should also be a condition for and an enabler to a trustworthy digital transformation of education.

References

Abrams, M. (2014), *The Origins of Personal Data and its Implications for Governance*, The Information Accountability Foundation, http://informationaccountability.org/wp-content/uploads/Data-Origins-Abrams.pdf (accessed on 12 April 2018). [4]

Altman, M.; A. Wood; D. O'Brien; S. Vadhan; U. Gasser (2015), "Towards a Modern Approach to Privacy-Aware Government Data Releases", *Berkeley Technology Law Journal*, Vol. 30/3, pp. 1967-2072, https://doi.org/10.15779/Z38FG17. [54]

Baker, R. (2021), "Artificial intelligence in education: Bringing it all together", in *OECD Digital Education Outlook 2021: Pushing the Frontiers with Artificial Intelligence, Blockchain and Robots*, OECD Publishing, Paris, https://doi.org/10.1787/f54ea644-en. [42]

Baker, R., A. Hawn and S. Lee (2023), "The state of the situation and policy recommendations for algorithmic bias", in *Digital Education Outlook 2023*, OECD Publishing. [36]

Boninger, F. and A. Molnar (2016), *Learning to be Watched: Surveillance Culture at School*, National Education Policy Center, Boulder, CO, http://nepc.colorado.edu/publication/schoolhouse-commercialism-2015. [25]

Buckley, J.; L. Colosimo; R. Kantar; M. McCall and E. Snow (2021), "Game-based assessment for education", in *OECD Digital Education Outlook 2021: Pushing the Frontiers with Artificial Intelligence, Blockchain and Robots*, OECD Publishing, Paris, https://doi.org/10.1787/9289cbfd-en. [5]

Burns, T. and F. Gottschalk (eds.) (2019), *Child protection online*, Educating 21st Century Children: Emotional Well-being in the Digital Age, OECD Publishing, Paris, https://doi.org/10.1787/b7f33425-en. [30]

Calo, R. (2011), "The Boundaries of Privacy Harm", *Indiana Law Journal*, Vol. 86/3, https://www.repository.law.indiana.edu/ilj/vol86/iss3/8/. [57]

Cavoukian, A. and K. El Emam (2011), *Dispelling the Myths Surrounding De-identification: Anonymization Remains a Strong Tool for Protecting Privacy*, http://www.ipc.on.ca/images/Resources/anonymization.pdf. [41]

Commission Nationale de l'Informatique et des Libertés (2017), *Rapport d'activité 2017*, https://www.cnil.fr/sites/default/files/atoms/files/cnil-38e_rapport_annuel_2017.pdf (accessed on 7 November 2019). [37]

D'Mello, S. (2021), "Improving student engagement in and with digital learning technologies", in *OECD Digital Education Outlook 2021: Pushing the Frontiers with Artificial Intelligence, Blockchain and Robots*, OECD Publishing, Paris, https://doi.org/10.1787/8a451974-en. [43]

Data Quality Campaign (2017), *Education Data Legislation Review The Role of State Legislation*, Data Quality Campaign, Washington, DC, https://2pido73em67o3eytaq1cp8au-wpengine.netdna-ssl.com/wp-content/uploads/2017/09/DQC-Legislative-summary-0926017.pdf (accessed on 9 January 2018). [29]

de Montjoye, Y.; C.A. Hidalgo; M. Verleysen and V. Blondel (2013), "Unique in the Crowd: The privacy bounds of human mobility", *Scientific Reports*, Vol. 3/1, p. 1376, https://doi.org/10.1038/srep01376. [13]

de Montjoye, Y.; L. Radaelli; V.K. Singh and A.S. Pentland (2015), "Unique in the shopping mall: on the reidentifiability of credit card metadata.", *Science*, Vol. 347/6221, pp. 536-9, https://doi.org/10.1126/science.1256297. [12]

Dillenbourg, P. (2021), "Classroom analytics: Zooming out from a pupil to a classroom", in *OECD Digital Education Outlook 2021: Pushing the Frontiers with Artificial Intelligence, Blockchain and Robots*, OECD Publishing, Paris, https://doi.org/10.1787/336f4ebf-en. [44]

Duhigg, C. (2012), "How Companies Learn Your Secrets - The New York Times", *The New York Times*, http://www.nytimes.com/2012/02/19/magazine/shopping-habits.html (accessed on 5 February 2018). [11]

Dwork, C.; A. Smith; T. Steinke and J. Ullman (2017), "Exposed! A Survey of Attacks on Private Data", *Annual Review of Statistics and Its Application*, Vol. 4/1, pp. 61-84, https://doi.org/10.1146/annurev-statistics-060116-054123. [15]

Dynarski, S. and M. Berends (2015), "Introduction to Special Issue: Research Using Longitudinal Student Data Systems: Findings, Lessons, and Prospects", *Educational Evaluation and Policy Analysis*, Vol. 37/1, https://doi.org/10.3102/0162373715575722. [39]

Elliot, M.; E. Mackey; K. O'Hara and C. Tudor (2016), *The anonymisation decision-making framework*, UK Anonymisation Network, Manchester, http://ukanon.net/wp-content/uploads/2015/05/The-Anonymisation-Decision-making-Framework.pdf (accessed on 4 January 2018). [53]

EU Data Protection Working Party (2017), *Guidelines on Automated individual decision-making and Profiling for the purposes of Regulation 2016/679*, European Commission, http://ec.europa.eu/justice/data-protection/index_en.htm. [32]

European Commission (2019), *Europeans' attitudes towards cyber security; Special Eurobarometer 499, European Union, October*. [21]

European Parliament (2021), *Artificial Intelligence Act*, https://www.europarl.europa.eu/doceo/document/TA-9-2023-0236_EN.html (accessed on 26 August 2023). [49]

Executive Office of the President (2014), *Big Data and Privacy: A Technological Perspective*, President's Council of Advisors on Science and Technology, https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/PCAST/pcast_big_data_and_privacy_-_may_2014.pdf (accessed on 25 June 2018). [16]

Figlio, D., K. Karbownik and K. Salvanes (2016), "Education Research and Administrative Data", in *Handbook of the Economics of Education*, Elsevier, https://doi.org/10.1016/B978-0-444-63459-7.00002-6. [38]

Future of Privacy Forum (2017), *Unfairness by Algorithm: Distilling the Harms of Automated Decision-Making*, Future of Privacy Forum, Washington. DC. [33]

García, D.; M. Goel; A. Agrawal and P. Kumaraguru (2018), "Collective aspects of privacy in the Twitter social network", *EPJ Data Science*, Vol. 7/1, p. 3, https://doi.org/10.1140/epjds/s13688-018-0130-3. [6]

Golle, P. (2006), *Revisiting the Uniqueness of Simple Demographics*, https://crypto.stanford.edu/~pgolle/papers/census.pdf. [58]

Groves, R. and B. Harris-Kojetin (eds.) (2017), *Federal Statistics, Multiple Data Sources, and Privacy Protection*, National Academies Press, Washington, D.C., https://doi.org/10.17226/24893. [8]

Information Commissioner's Office (2017), *Feedback request – profiling and automated decision-making*. [34]

Information is Beautiful (2019), *World's Biggest Data Breaches and Hacks*, https://informationisbeautiful.net/visualizations/worlds-biggest-data-breaches-hacks/ (accessed on 23 October 2019). [19]

Jardine, E. (2015), *Global Cyberspace Is Safer than You Think: Real Trends in Cybercrime*, Global Commission on Internet Governance, https://www.cigionline.org/sites/default/files/no16_web_0.pdf (accessed on 5 February 2018). [20]

Narayanan, A. and V. Shmatikov (2008), *Robust De-anonymization of Large Sparse Datasets*, IEEE Computer Society, Washington, DC, https://doi.org/10.1109/SP.2008.33. [10]

NCES (2011), *Data Stewardship: Managing Personally Identifiable Information in Electronic Student Education Records*, National Centre for Education Statistics (NCES). [7]

OECD (2023), *OECD Digital Education Outlook 2023: Towards an Effective Digital Education Ecosystem*, OECD Publishing, Paris, https://doi.org/10.1787/c74f03de-en. [1]

OECD (2023), *OECD Digital Education Outlook 2023: Towards an Effective Digital Education Ecosystem*, OECD Publishing, Paris, https://doi.org/10.1787/c74f03de-en. [45]

OECD (2023), "Regulatory sandboxes in artificial intelligence", *OECD Digital Economy Papers*, No. 356, OECD Publishing, Paris, https://doi.org/10.1787/8f80a0e6-en. [48]

OECD (2021), *OECD Digital Education Outlook 2021: Pushing the Frontiers with Artificial Intelligence, Blockchain and Robots*, OECD Publishing, Paris, https://doi.org/10.1787/589b283f-en. [35]

OECD (2019), "OECD AI Principles overview", *OECD.AI Policy Observatory*, https://oecd.ai/en/ai-principles. [46]

OECD (2016), "Managing Digital Security and Privacy Risk", *OECD Digital Economy Papers*, No. 254, OECD Publishing, Paris, https://doi.org/10.1787/5jlwt49ccklt-en. [17]

OECD (2015), *Digital Security Risk Management for Economic and Social Prosperity: OECD Recommendation and Companion Document*, OECD Publishing, Paris, https://doi.org/10.1787/9789264245471-en. [52]

OECD (2015), *Health Data Governance: Privacy, Monitoring and Research*, OECD Health Policy Studies, OECD Publishing, Paris, https://doi.org/10.1787/9789264244566-en. [56]

OECD (2013), *OECD Revised Guidelines on the Protection of Privacy and Transborder Flows of Personal Data*, http://www.oecd.org/sti/ieconomy/oecd_privacy_framework.pdf (accessed on 12 January 2018). [2]

OECD (2013), *Strengthening Health Information Infrastructure for Health Care Quality Governance: Good Practices, New Opportunities and Data Privacy Protection Challenges*, OECD Publishing, Paris, https://doi.org/10.1787/9789264193505-en. [55]

OECD (2013), *The OECD Privacy Framework*, https://www.oecd.org/sti/ieconomy/oecd_privacy_framework.pdf. [3]

Office of Education Technology (OET) (2023), *AI and the Future of Teaching and Learning*, https://tech.ed.gov/files/2023/05/ai-future-of-teaching-and-learning-report.pdf. [50]

Office of Management and Budget (United States) (2016), *Commission on Evidence based Policymaking*, https://obamawhitehouse.archives.gov/omb/management/commission_evidence (accessed on 24 November 2023). [40]

Office of the Privacy Commissioner of Canada (2015), *Privacy Act Annual Report to Parliament 2014-15*, Office of the Privacy Commissioner of Canada, https://www.priv.gc.ca/en/opc-actions-and-decisions/ar_index/201415/201415_pa/#heading-0-0-2 (accessed on 13 April 2018). [18]

Pew Research Center (2023), *Growing public concern about the role of artificial intelligence in daily life*, https://www.pewresearch.org/short-reads/2023/08/28/growing-public-concern-about-the-role-of-artificial-intelligence-in-daily-life/ (accessed on 29 August 2023). [22]

Pew Research Center (2019), *Americans and Privacy: Concerned, Confused and Feeling Lack of Control Over Their Personal Information*, https://www.pewresearch.org/internet/2019/11/15/americans-and-privacy-concerned-confused-and-feeling-lack-of-control-over-their-personal-information/ (accessed on 29 August 2023). [23]

Polonetski, J. and J. Jerome (2014), *Student Data: Trust, Transparency, and the Role of Consent*, Future or Privacy Forum. [24]

Rocher, L., J. Hendrickx and Y. de Montjoye (2019), “Estimating the success of re-identifications in incomplete datasets using generative models”, *Nature Communications*, Vol. 10/1, https://doi.org/10.1038/s41467-019-10933-3. [14]

Singer, N. (2017), “How Google Took Over the Classroom”, *New York Times*, https://www.nytimes.com/2017/05/13/technology/google-education-chromebooks-schools.html. [26]

Singer, N. (2014), “With Tech Taking Over in Schools, Worries Rise”, *The New York Times*, https://www.nytimes.com/2014/09/15/technology/with-tech-taking-over-in-schools-worries-rise.html (accessed on 25 January 2018). [28]

Solove, D. (2006), “A Taxonomy of Privacy”, *University of Pennsylvania Law Review*, Vol. 154/3, pp. 477-560, https://www.law.upenn.edu/journals/lawreview/articles/volume154/issue3/Solove154U.Pa.L.Rev.477(2006).pdf (accessed on 15 March 2018). [31]

Sweeney, L. (1997), “Weaving Technology and Policy Together to Maintain Confidentiality”, *The Journal of Law, Medicine & Ethics*, Vol. 25/2-3, pp. 98-110, https://doi.org/10.1111/j.1748-720X.1997.tb01885.x. [9]

UNESCO (2021), *Recommendation on the Ethics of Artificial Intelligence*, https://unesdoc.unesco.org/ark:/48223/pf0000380455. [47]

White House Office of Science and Technology Policy (WHOSTP) (2022), *Blueprint for an AI Bill of Rights: Making Automated Systems Work for the American People*, White House, https://www.whitehouse.gov/wp-content/uploads/2022/10/Blueprint-for-an-AI-Bill-of-Rights.pdf. [51]

Zeide, E. and H. Nissenbaum (2018), “Learner Privacy in MOOCs and Virtual Education”, *Theory and Research in Education*, Vol. 16/3, pp. 280-307, https://doi.org/10.1177/1477878518815340. [27]

Notes

[1] A follow-up study suggests that more than 50% of the population in the United States can be uniquely identified using these three pieces of information (Golle, 2006[58]).

[2]See blogpost by Melanie Lazare (Feb 2021): https://blog.google/outreach-initiatives/education/classroom-roadmap/#:~:text=Over%20the%20last%20year%2C%20the,from%2040%20million%20last%20year. And https://www.digitaltrends.com/web/google-g-suite-70-million/.

[3] https://edu.google.com/k-12-solutions/privacy-security [Accessed 23/08/2018]

[4] Moreover, large technology companies tend to operate worldwide while data protection regimes vary across countries. The GDPR establishes that when personal data are transferred from the EU to controllers, processors or other recipients in third countries or to international organisations, such transfers to and processing in third countries and international organisations may only be carried out in full compliance with the GDPR.

[5] Privacy breaches (or violations) are different from privacy harms. Not all breaches cause harm, and harm may occur in the absence of a privacy breach. Calo (2011[57]) distinguishes between subjective and objective privacy harms. Subjective harms are unwelcome mental states such as embarrassment or fear that follow from unwanted observation. Objective harms are unanticipated or coerced use of information concerning a person against that person, for example identity theft.

[6] There are multiple strategies to turn identifiable data into non-identifiable data. ‘De-identification’ refers to the removal or obscuring of personal identifiers, either direct or indirect. ‘Anonymization’ is a broader concept that encompasses other statistical disclosure limitation techniques and regulations for data access and use. See Glossary for details.

[7] Re-identification refers to discovering the identity of an individual in a dataset where this information was not initially disclosed. If this discovery comes about against the will of the data subject, then his or her privacy is not preserved.

[8] https://digital-strategy.ec.europa.eu/en/policies/data-governance-act.

[9] https://oecd.ai/en/ai-principles

9 Algorithmic bias: the state of the situation and policy recommendations

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This chapter discusses the current state of the evidence on algorithmic bias in education. After defining algorithmic bias and its possible origins, it reviews the existing international evidence about algorithmic bias in education, which has focused on gender and race, but has also involved some other demographic categories. The chapter concludes with a few recommendations, notably to ensure that privacy requirements do not prevent researchers and developers from identifying bias, so that it can be addressed.

Introduction

Concern about the problem of algorithmic bias has increased in the last decade. Algorithmic bias occurs when an algorithm encodes (typically unintentionally) the biases present in society, producing predictions or inferences that are clearly discriminatory towards specific groups (Executive Office of the President, 2014[1]; O'Neil, 2016[2]; Zuiderveen Borgesius, 2018[3]). This concern has emerged across domains from criminal justice (Angwin et al., 2016[4]), to medicine (O'Reilly-Shah et al., 2020[5]) to computer vision (Klare et al., 2012[6]), to hiring (Garcia, 2016[7]).

Research has demonstrated that algorithmic bias is a problem for algorithms used in education as well. Academics have been warning about possible uneven effectiveness and lack of generalizability across populations in educational algorithms for several years (e.g. (Bridgeman, Trapani and Attali, 2009[8]; Ocumpaugh and Heffernan, 2014[9])). In education, algorithmic bias can manifest in several ways. For instance, an algorithm used in testing to identify English language proficiency may systematically underrate the proficiency of learners from some countries (Wang, Zechner and Sun, 2018[10]; Loukina, Madnani and Zechner, 2019[11]), denying them access to college admission. To give another example, an algorithm identifying if learners are at risk of failing a course may underestimate the risk of learners in specific demographic groups (Hu and Rangwala, 2020[12]; Kung and Yu, 2020[13]; Yu et al., 2020[14]), denying them access to needed support.

This concern has led to increasing interest in addressing algorithmic bias in education, both in academia and industry. A rapidly increasing number of publications in this area is a testimony to the increasing academic interest in this topic. Active, even fervent debate, is ongoing about how best to measure algorithmic bias (Caton and Haas, 2020[15]; Mehrabi et al., 2021[16]; Verma and Rubin, 2018[17]) and which technical approaches can correct bias (Kleinberg, Mullainathan and Raghavan, 2016[18]; Loukina, Madnani and Zechner, 2019[11]; Lee and Kizilcec, 2020[19]). Within industry and the NGO sector, efforts such as the Prioritizing Racial Equity in AI Design Product Certification from Digital Promise (Digital Promise, 2022[20]) demonstrate the efforts being made to systematize the process of reducing algorithmic bias, and several companies have actively published evidence about the algorithmic bias in their tools and platforms, sometimes in cooperation with academics (Bridgeman, Trapani and Attali, 2009[8]; Bridgeman, Trapani and Attali, 2012[21]; Christie et al., 2019[22]; Zhang et al., 2022[23]). There has not yet been comparable interest in addressing algorithmic bias in education within the policy space – if anything, current directions in policy are towards adopting privacy regulations that will make it impossible to fix the problem of algorithmic bias in education, by making it impossible to collect the data needed to identify if it is occurring and to apply common methods for fixing it when it occurs – see a review of this issue in (Baker and Hawn, 2022[24]).

Despite the increasing concern about algorithmic bias in education, however, work to determine its scope and address it has remained limited. While an increasing number of papers look into algorithmic bias in education, as this review will illustrate, this research is highly uneven in focus. The overwhelming majority of work on algorithmic bias in education focuses on the impacts on a small number of racial and ethnic groups and on sex (Baker and Hawn, 2022[24]), with most effort going into the demographic variables that are most conveniently available to researchers (Belitz et al., 2022[25]). Work in this area is also extremely focused on algorithms used in a single country, the United States of America (Baker and Hawn, 2022[24]). The work that exists shows clear evidence that groups already disadvantaged societally are further disadvantaged by current educational technologies, a problem that requires action. But we do not yet know the full extent of the problem.

In this chapter, we discuss the current state of the evidence on algorithmic bias in education, key obstacles to creating fair algorithms, and steps that can be taken to surpass these obstacles. We conclude with recommendations for policy makers for what they can do to help resolve this still mostly hidden societal problem.

What is algorithmic bias?

Defining algorithmic bias

A recent survey across 146 papers found a lack of clarity in how authors define and use the term *bias*, from gaps of explanation as to how exactly systems are biased to confusion about the eventual harms that bias might cause (Crawford, 2017[26]; Blodgett et al., 2020[27]). We will briefly discuss some of the issues in defining *algorithmic bias* before proposing a limited working definition applied in this paper.

Algorithmic bias in emerging use

The term *algorithmic bias* has been used to describe many problems of fairness in automated systems, only some of which map onto statistical or technical definitions of bias. Some researchers define the term broadly, referring to *biases* as the set of possible harms throughout the machine-learning process, including any "unintended or potentially harmful" properties of the data that lead to "unwanted or societally unfavourable outcome[s]" (Suresh and Guttag, 2021[28]). Others apply *algorithmic bias* in a more limited way to cases where a model's performance or behaviour differs systematically between groups (Gardner, Brooks and Baker, 2019[29]; Mitchell et al., 2020[30]). This second definition of algorithmic bias – systematic skew in performance – may or may not lead to harmful disparate impacts or discrimination, depending on how model results are applied.

Because of this potential for algorithmic bias to translate into unintended impacts, the machine-learning process should be conducted with caution, anticipating some of the very real damages that may result from bias. A widely accepted framework for such harms categorises them broadly into allocative and representational forms (Crawford, 2017[26]; Suresh and Guttag, 2021[28]).

Allocative harms result from the withholding or the unfair distribution of some opportunity across groups, with examples including gender bias in assigning credit limits (Knight, 2019; Telford, 2019); racial bias in sentencing decisions (Angwin et al., 2016[4]) racial bias in identifying patients for additional health care (Obermeyer et al., 2019[31]), and – in education – bias in standardised testing and its resulting impact on high-stakes admission decisions (Dorans, 2010[32]; Santelices and Wilson, 2010[33]).

Representational harms, on the other hand, manifest as the systematic representation of some group in a negative light, or by withholding positive representation (Crawford, 2017[26]). Multiple forms of representational harm have been uncovered in recent years, with Sweeney (2013[34]) identifying varieties of *denigration* and *stereotyping*, where, for instance, the word "criminal" was more frequently returned in online ads after searches for black-identifying first names.

While there are clearly a range of ways that *algorithmic bias* is discussed, here we focus on algorithmic bias in situations where model performance is substantially better or worse across mutually exclusive groups (i.e. (Gardner, Brooks and Baker, 2019[29]; Mehrabi et al., 2021[16]; Mitchell et al., 2020[30])). Other forms of algorithmic bias (such as the cases mentioned above) can be highly problematic, but – as we discuss below – the published research in education thus far has focused on this performance-related version of bias. In this review, we also home in on bias in algorithms, excluding the broader design of the learning or educational systems that use these algorithms. Bias can also emerge in the design of learning activities, leading to differential impact for different populations (Finkelstein et al., 2013[35]), but that is a much broader topic, beyond what this review covers.

How this type of algorithmic bias is identified

Though the origins of algorithmic bias are complex, and solving or mitigating it can in some cases be challenging, identifying algorithmic bias related to model performance is relatively straightforward. Doing so requires only two steps: 1) obtaining data on student identity; 2) checking model performance for students belonging to different groups.

The first step poses some challenges in terms of concerns around student privacy (Pardo and Siemens, 2014[36]) and policies designed to protect student privacy (Baker, 2022[37]). If data on student identity and membership in key demographic groups was not collected initially, it can be difficult to collect after the fact. Once the data has been split into members of different groups, and the model has been applied to those learners, the results can be checked for differences in performance. There are a range of measures that can be used (Kizilcec and Lee, 2022[38]), and ideally several will be used in concert. First, the same measures generally used to evaluate algorithm performance – AUC ROC, Kappa, F1, precision, recall, and so on – can also be used to evaluate performance for sub-groups. Second, some measures specific to algorithmic bias analysis – ABROCA (Gardner, Brooks and Baker, 2019[29]), independence, separation, sufficiency, for instance – can be applied.

After examining the metrics for the differences in algorithm performance between groups, it becomes possible to analyse the expected impacts, anticipating the ways that algorithmic bias might lead to a biased response or intervention. For example, if an algorithm for predicting high school drop-out achieves 20% poorer recall (the ability to identify all individuals at risk) for members of a historically disadvantaged group, then we know that many students in the group who are at risk and need an intervention will not receive it. By contrast, if the same algorithm were to achieve 20% poorer precision (the ability to avoid selecting an individual not at risk) for members of a historically disadvantaged group, then many students in the group will receive unnecessary interventions, at best wasting their time. Checking for expected impacts also gives a sense of what would be gained by fixing a specific bias identified, and ensures that work spent to address algorithmic biases, if successful, will increase the fairness and overall benefit of using the algorithm.

Bias against whom?

Researchers have considered a range of groups which have been, or could be, impacted by algorithmic bias. Many of these groups have been defined by characteristics protected by law. In the United Kingdom, for instance, the Equality Act of 2010 merged over a hundred disparate pieces of legislation into a single legal framework, unifying protections against discrimination on the basis of sex, race, ethnicity, disability, religion, age, national origin, sexual orientation, and gender identity. In the United States, the same categories are protected by a combination of different legislation, commission rulings, and court rulings, dating back to the Civil Rights Act of 1964. Similar laws afford protections in the European Union and most other countries around the world, though differing in which groups are protected and how they are defined.

While preserving fairness for these legally defined groups is critical, looking for bias only under the lamppost of nationally protected classes (categories with their own complicated histories) may leave other, under-investigated, groups open to bias and harm. Other researchers have suggested additional characteristics which may be vulnerable to algorithmic bias in education: urbanicity (Ocumpaugh and Heffernan, 2014[9]), military-connected status (Baker, Berning and Gowda, 2020[39]), or speed of learning (Doroudi and Brunskill, 2019[40]). Existing legal frameworks used to decide which classes of people merit protection from discrimination may be helpful in assessing the unknown risks that algorithmic bias poses to less studied or unidentified groups (Soundarajan and Clausen, 2018[41]). Section 4 reviews the limited education research into algorithmic bias associated with other groups.

Origins of bias and harm in the machine-learning pipeline

In an effort to better catalogue the origins of algorithmic bias, researchers have described the stages of the machine-learning life-cycle alongside the kinds of bias and harm that can arise at each stage (Barocas, Hardt and Narayanan, 2019[42]; Friedman and Nissenbaum, 1996[43]; Hellström, Dignum and Bensch, 2020[44]; Mehrabi et al., 2021[16]; Silva and Kenney, 2019[45]; Suresh and Guttag, 2021[28]). While some authors collapse the machine-learning process into broader stages (e.g., *measurement*, *model learning*, and *action)* (Barocas, Hardt and Narayanan, 2019[42]; Kizilcec and Lee, 2022[38]), others delimit finer-grained stages, such as *data collection*, *data preparation*, *model development*, *model evaluation*, *model post-processing*, and *model deployment* (Suresh and Guttag, 2021[28]). Industry researchers, in turn, have offered additional stages more common to applied contexts, such as *Task Definition*, *Dataset Construction*, *Testing Process*, *Deployment*, and ongoing *Feedback* from users (Cramer et al., 2019[46]).

At each of these stages, particular forms of bias can arise. Examples include historical bias, representation bias, measurement bias, aggregation bias, evaluation bias, and deployment bias (Suresh and Guttag, 2021[28]). By grounding aspirational, goal-driven algorithms in data from an historically inequitable world, *historical bias* is often perpetuated in education. The most common example, perhaps, is using student demographics as a feature to increase model performance, with the result of lowering the predicted grades for some students based on membership in a demographic group (i.e. (Wolff et al., 2013[47])). A recent survey of the role of demographics in educational data mining, finds that roughly half of papers incorporating demographics into models as features risk this form of bias, using at least one demographic attribute as a predictive feature without considering demographics during model testing or validation (Paquette et al., 2020[48]).

Representational bias occurs when groups under-sampled in training data receive lower-performing predictions. *Measurement bias* occurs when the selected variables lack construct validity in a way that leads to unequal prediction across groups. A model predicting school violence, for example, might be biased if the labelling of which students engage in violence involves prejudice – e.g. the same violent behaviour is documented for members of one race but not for members of another (Bireda, 2002[49]).

Past the data collection stages of machine-learning, the model learning phase is susceptible to *aggregation bias*, when training data from distinct populations are combined, with the resulting model working less well for some – or all – groups of learners (Suresh and Guttag, 2021[28]). When detectors of student emotion, for instance, were trained on a combination of urban, rural, and suburban students, they functioned more poorly for all three groups than detectors trained on individual groups (Ocumpaugh and Heffernan, 2014[9]). In the application phases of machine-learning, *evaluation bias* occurs when the test sets used to evaluate a model fail to represent the populations with which the model will be applied, and *deployment bias* occurs when a model designed for one purpose is used for other tasks, such as applying a model designed to help teachers identify student disengagement as a tool to assign summative participation grades to students.

Increasing research and journalism has exposed these forms of algorithmic bias in areas such as at-risk prediction for dropping out of high school or college (Anderson, Boodhwani and Baker, 2019[50]), at-risk prediction for failing a course (Hu and Rangwala, 2020[12]; Lee and Kizilcec, 2020[19]), automated essay scoring (Bridgeman, Trapani and Attali, 2009[8]; Bridgeman, Trapani and Attali, 2012[21]), assessment of spoken language proficiency (Wang, Zechner and Sun, 2018[10]), and the detection of student emotion (Ocumpaugh and Heffernan, 2014[9]). In these cases and others, reviewed below, algorithmic bias has impacted educational algorithms in terms of student race, ethnicity, nationality, gender, native language, urbanicity, parental educational background, socio-economic status, and whether a student has a parent in the military. This evidence has prompted increasing academic and industry research into the ways that algorithmic bias can be more effectively identified, mitigated, and its harms reduced.

Mitigating bias by formalising fairness

Much current work addressing algorithmic bias has focused on mitigation at the model evaluation and post-processing stages of the machine-learning process. Recent surveys present several taxonomies and definitions of fairness with related metrics (Barocas, Hardt and Narayanan, 2019[42]; Caton and Haas, 2020[15]; Kizilcec and Lee, 2022[38]; Mehrabi et al., 2021[16]; Mitchell et al., 2020[30]; Verma and Rubin, 2018[17]). While these formalised metrics make a clear contribution to clarifying algorithmic bias, their application has revealed obstacles. Specifically, technical challenges to the use of fairness metrics manifest in several “impossibility” results (Chouldechova, 2017[51]; Kleinberg, Mullainathan and Raghavan, 2016[18]; Berk et al., 2018[52]; Loukina, Madnani and Zechner, 2019[11]; Lee and Kizilcec, 2020[19]; Darlington, 1971[53]), where satisfaction of one statistical criterion of fairness makes it impossible to satisfy another. For instance, Kleinberg et al. (2016[18]) demonstrate that it is mathematically impossible under normal conditions for a risk estimate model to avoid all three of the following undesirable properties: 1) systematically skewing upwards or downwards for one demographic group; 2) assigning a higher average risk estimate to individuals not at risk for one group than the other; 3) assigning a lower average risk estimate to individuals who are at risk in one group than the other.

Other challenges for this pathway to mitigating bias include the difficulty in describing optimal trade-offs in fairness for domain-specific problems (Lee and Kizilcec, 2020[19]; Makhlouf, Zhioua and Palamidessi, 2021[54]; Suresh and Guttag, 2021[28]), as well as the sociotechnical critique that an overemphasis on seemingly objective, statistical criteria for fairness may provide an excuse for developers and users of algorithms to avoid grappling with the full range of potential bias and harms from employing algorithms for high-stakes decisions (Green, 2020[55]; Green and Hu, 2018[56]; Green and Viljoen, 2020[57]). In order to address the fuller picture of algorithmic bias, it is critical to identify and mitigate bias, not only during the later stages of the process, but also during the earlier stages of data collection and data preparation.

Representational and measurement biases: the key role for data collection

Attempts to address algorithmic bias solely by adjusting algorithms may be ineffective if we have not collected the right data. Specifically, representational and measurement bias (Suresh and Guttag, 2021[28]) can prevent methods further down the pipeline from resolving, or even detecting, bias.

As a key example, if we collect training data only from suburban upper middle-class children, we should not expect our model to work for urban lower-income students. More broadly, if we do not collect data from the right sample of learners, we risk representational bias and cannot expect our models to work for all learners.

Measurement bias is another significant challenge that improved metrics or algorithms cannot overcome on their own. While measurement bias can occur in both predictor variables and training labels (Suresh and Guttag, 2021[28]), the most concerning cases involve the latter. If, for instance, Black students behave similarly to students from other groups, but are still more likely to be *labelled* in a dataset as engaging in school violence, then it is difficult to determine whether an algorithm works equally well for both groups, or to be at all confident that the algorithm’s functioning is not biased. Surprisingly, this bias in training labels may even come from students themselves if the label depends on students’ responses and can be impacted by confidence, cultural interpretation, or stereotype threat (Tempelaar, Rienties and Nguyen, 2020[58]). In these cases, finding an alternate variable to predict – one not as impacted by bias – may be the best alternative. Other cases of measurement bias may be easier to mitigate, such as when human coders, impacted by their own bias (Kraiger and Ford, 1985[59]; Okur et al., 2018[60]), label some aspect of previously collected data. In the situation where predictor variables are biased, they may be substituting for other variables that would explicitly define group membership, in which case it may be best to discard the biased predictors from consideration.

Ultimately, the best path to addressing both representational and measurement bias is to collect better data – data that includes sufficient proportions of relevant groups, and in which key variables are not themselves biased (Cramer et al., 2019[46]; Holstein et al., 2019[61]). Completing this task, however, depends on knowing what groups are critical to represent in the data sets used to develop models, the focus of our next section.

Algorithmic bias: impact on students in common demographic categories

A great majority of research has focused on a limited number of groups within the diverse student population, focusing on variables involving race and ethnicity, nationality, and gender (Baker and Hawn, 2022[24]). Race and ethnicity, nationality and gender, unsurprisingly, represent the most common demographic categories or variables collected by or made available to researchers, whether by convention or for convenience, especially as most research was conducted in the United States.

Within these broad categories, there is some variance in how the variables are considered. At times, specific racial groups are considered and other times they are considered in terms of whether a student is an URM (Under-Represented Minority) or not. Although a minority in most studies, Asians are typically treated as non-URM in US educational research. Even when racial groups are separated in analysis, heterogeneity within these groups is typically ignored (i.e. people whose ancestors have lived in their current country for generations versus recent immigrants; individuals with different national origins with very different histories and cultures; (Baker et al., 2019[62])).

In this section, we will examine the evidence on algorithmic bias in education by addressing which groups of students have been systematically impacted, in terms of these most common categories. The overview will be organised into the different locations in the world in which each study was conducted, in order to illustrate the uneven amount of research on algorithmic bias in education that has occurred in different regions. We will discuss the implications of that unevenness, and how to address it, later in this chapter.

Algorithmic bias in education in the United States (Widely studied categories)

The majority of research on algorithmic bias in education thus far has been conducted in the United States The strong interest in documenting and addressing algorithmic bias in the United States maps to broader societal concern in the United States about algorithmic bias (Corbett-Davies and Goel, 2018[63]) and discrimination in general (Barocas, Hardt and Narayanan, 2019[42]; O'Neil, 2016[2]). It also may reflect the relatively high availability of educational data for research purposes in the United States. Even most of the research on how learners from different nationalities are impacted by research on algorithmic bias has often been conducted in the United States (Bridgeman, Trapani and Attali, 2009[8]; Bridgeman, Trapani and Attali, 2012[21]; Li et al., 2021[64]; Ogan et al., 2015[65]; Wang, Zechner and Sun, 2018[10]).

Within the United States, a considerable amount of research has investigated the impact of algorithmic bias in education on different racial groups. A recent review by Baker and Hawn (2022[24]) identifies ten cases where this was investigated, across algorithms for purposes ranging from predicting dropout (Anderson, Boodhwani and Baker, 2019[50]; Christie et al., 2019[22]; Kai et al., 2017[66]; Yu, Lee and Kizilcec, 2021[67]), predicting course failure (Lee and Kizilcec, 2020[19]; Yu et al., 2020[14]), and automated essay scoring (Bridgeman, Trapani and Attali, 2009[8]; Bridgeman, Trapani and Attali, 2012[21]; Ramineni and Williamson, 2018[68]). Typically, across studies, algorithms were less effective for Black and Hispanic/Latino students in general (Anderson, Boodhwani and Baker, 2019[50]; Bridgeman, Trapani and Attali, 2012[21]; Lee and Kizilcec, 2020[19]; Ramineni and Williamson, 2018[68]; Yu, Lee and Kizilcec, 2021[67]), and often also had different profiles of false positive and negative results for students in different racial groups (Anderson, Boodhwani and Baker, 2019[50]). More recently, the Penn Center for Learning Analytics (PCLA) wiki (Penn Center for Learning Analytics, n.d.[69]) has identified an additional six studies (published since (Baker and Hawn[24])was finalised) on this topic. Curiously, smaller effects were seen in many of these more recent studies than in earlier studies, which may suggest either that there were some "file drawer" problems with earlier work (that is, results with small effects were not published in the past), or that a broader range of possible contexts are being investigated.

Though there has been considerable attention to race in general, less quantity of research has been paid to indigenous learners, often due to issues of sample size (Anderson, Boodhwani and Baker, 2019[50]), though notable counter-examples exist (e.g. (Christie et al., 2019[22])).

Within the United States, considerable research has also investigated the impact of algorithmic bias in education in terms of learners with different genders. Baker and Hawn (2022[24]) identified nine cases, and three additional papers have been identified since then by the PCLA wiki. Across these papers, gender effects were highly inconsistent, with significant biases against females in some cases (Gardner, Brooks and Baker, 2019[29]; Yu et al., 2020[14]) and significant biases against males in other cases (Hu and Rangwala, 2020[12]; Lee and Kizilcec, 2020[19]; Kai et al., 2017[66]).

Algorithmic bias in education in Europe (Widely studied categories)

While race has been used as a predictor variable in Europe (Wolff et al., 2013[47]), it has not been the subject of systematic investigation into algorithmic bias in education. Research into how algorithmic bias impacts learners from different nationalities has also not been carried out in Europe, to the best of our knowledge, although Bridgeman and colleagues (2009[8]; 2012[21]) investigated algorithmic bias in automated essay scoring on learners from around the world, including several European countries, finding that learners from European countries were less impacted than learners in Asia. However, Wang, Zechner and Sun (2018[10]) found substantial inaccuracies in speech evaluation for learners from Germany, and Li et al. (2021[64]) found that academic achievement prediction was less effective for learners from Moldova than learners in wealthier countries.

However, research on algorithmic bias in terms of gender has occurred in Europe: Riazy et al. (2020[70]) investigated the impacts of gender on course outcome prediction and Rzepka et al. (2022[71]) investigated the impacts of gender on prediction conducted during a spelling learning activity. Only small effects were found.

Overall, then, there is not yet evidence for major impacts of algorithmic bias in Europe, in terms of race, nationality, or gender, but there also have been few studies, and these studies do not cover the range of applications which research in the United States has investigated.

Algorithmic bias in education in the rest of the world (Widely Studied Categories)

Multiple studies of algorithmic bias in terms of nationality have been conducted on learners from around the world, though primarily involving researchers based in the United States. Baker and Hawn (2022[24]) identified four such studies. These studies have involved a range of applications, from predicting academic achievement (Li et al., 2021[64]), to automated essay scoring (Bridgeman, Trapani and Attali, 2009[8]; Bridgeman, Trapani and Attali, 2012[21]), to speech evaluation (Wang, Zechner and Sun, 2018[10]), to models of help-seeking (Ogan et al., 2015[65]). The studies have documented biases impacting learners from China, Korea, India, Vietnam, the Philippines, Costa Rica, and individuals living in countries where the primary language is Arabic. These studies have been fairly different from each other (except for the two Bridgeman et al. studies) and have documented a range of patterns, clearly indicating that considerably more research is needed.

Three studies on algorithmic bias in education in terms of gender have been conducted outside of the United States and Europe. Verdugo and colleagues (2022[72]) found bias in algorithms predicting university dropout in Chile, negatively impacting female students. Sha and colleagues (2021[73]; 2022[74]) investigate algorithms for four different applications in Australia, finding substantial gender biases but not always in the same direction.

Box 9.1. Three examples of algorithmic bias in education

Automated essay scoring used in a high-stakes examination (the Test of English as a Foreign Language) was found to systematically rate essays differently than human graders. Specifically, the algorithm rated native speakers of Arabic, Hindi, and Spanish lower than students from other countries, relative to human graders. The algorithm had been used to replace one of two human coders. In response to this evidence, the test developer instituted a new practice: First a single human grader and the machine rate the essay. If the human and machine give substantially different ratings, a second human rates the essay. If the two humans agree, the automated score is discarded (Bridgeman, Trapani and Attali, 2012[21]).

A model predicting first-year dropout from a Chilean university was found to perform more poorly for female students and students who attended private high schools. A range of fairness techniques were applied, improving the equity of model performance, and in turn the equity of the provision of dropout supports to students (Vasquez Verdugo et al., 2022[72]).

Models detecting student affect (whether a student was bored, frustrated, confused, or engaged) within an online learning platform were found to perform more poorly for students in rural communities than for students in urban or suburban communities. By creating a model tailored to rural students, model performance was improved for this group of students. The models are being used to conduct learning engineering research on how to improve the design of learning content; reducing inequities in the models reduces the risk that incorrect design decisions are made (Ocumpaugh and Heffernan, 2014[9]).

Algorithmic bias: impact on students in other categories

While the majority of research on algorithmic bias in education has investigated race and ethnicity, nationality and gender, other categories of identity have also been investigated. In this section, we will examine the evidence for algorithmic bias in education impacting learners in these categories. Across studies, researchers have investigated algorithmic bias in terms of learners' urbanicity (city or rural area), socio-economic status, type of school attended (public or private), native language, disabilities, parental educational background, military-connected status. These variables have generally not been investigated in sufficient detail to draw solid conclusions. As with race and ethnicity, nationality and gender, the majority of studies occurred in the United States (15 studies), compared to three in Europe and two in the rest of the world.

According to the PCLA wiki, four studies have thus far investigated native language in terms of algorithmic bias in education: two in the United States (Naismith et al., 2019[75]; Loukina, Madnani and Zechner, 2019[11]), one in Europe (Rzepka et al., 2022[71]), and one in Australia (Sha et al., 2021[73]). Three of four studies found evidence for algorithmic biases negatively impacting non-native speakers, but one (Rzepka et al., 2022[71]) found slightly better model accuracy for non-native speakers. All four studies involved educational tasks where the use of language was central (essay-writing, speaking, spelling, and posting to discussion forums).

The PCLA wiki identified five studies on parental educational background, four in the United States and one in Europe. All five show differences in model performance and prediction in terms of this variable, but the ways that bias manifest are inconsistent across studies, with some studies finding better performance for students with more educated parents but other studies finding better performance for students with less educated parents.

The PCLA wiki also identifies five studies on socio-economic status, all five conducted in the United States. Four of the five papers (predicting dropout, grade point average [GPA], and learning) find that algorithms are less effective for students with poorer socio-economic backgrounds, but the fifth (on automated essay scoring) finds no evidence of difference. A sixth study conducted in Chile, on whether students are attending public or private schools (highly associated with socio-economic status), finds that models predicting university dropout are more accurate for learners from public schools.

There has been relatively little research on how algorithmic bias impacts learners with disabilities. In the United States, Baker and Hawn (2022[24]) document a single study, by Loukina and Buzick (2017[76]), which found that a system for assessing proficiency in spoken English was less accurate for students who were identified by test administrators to have a speech impairment.

In Europe, Baker and Hawn (2022[24]) also document a single study, by Riazy et al. (2020[70]), who found that a system for predicting course outcomes had systematic inaccuracies for learners with self-declared disabilities. These two studies clearly do not cover the range of disabilities that may lead to algorithmic bias in education, and no studies have been documented outside the United States and Europe.

According to the PCLA wiki, two studies have investigated algorithmic bias in terms of student urbanicity (urban versus rural), both in the United States. Ocumpaugh and colleagues (2014[9]) find that models predicting student emotion are less effective if they are developed using data from urban learners and then tested on data from rural learners, compared to if they are tested on data from unseen urban learners. The same is true if the model is developed using data from rural learners and tested on data from urban learners. However, Samei and colleagues (2015[77]) find that models on classroom discourse do not differ between urban and rural settings. More research is needed to determine which types of prediction are impacted when going between urban and rural settings.

Finally, one study conducted in the United States finds that models predicting graduation and standardised examination scores are less accurate for students with family members in the military (Baker, Berning and Gowda, 2020[39]). Across these studies, a variety of variables are investigated and there is on the whole evidence that algorithmic bias has impacts that go beyond race/ethnicity, gender, and nationality. A range of variables have not yet been investigated at all, including religion, age, children of migrant workers, specific disabilities beyond speech impairment, transgender status, and sexual orientation.

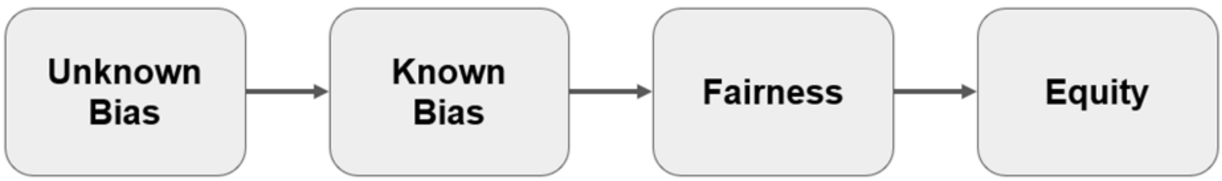
From unknown bias to known bias, from fairness to equity

The previous sections of this chapter outline what is currently known to the field about how algorithmic bias is manifesting in education. Our review indicates that there is clear evidence that algorithmic bias is manifesting in many ways, but also indicates how limited our current knowledge is. Many potential areas of algorithmic bias are documented in just a single article, and many potential areas where algorithmic bias could be occurring have not yet been studied at all. There also is no clear sense as to the magnitude of the problem for different use cases and groups of students.

As Baker and Hawn (2022[24]) note, we are at the very beginning of a progression in fixing the problem of algorithmic bias. At first, there is *unknown bias* – a problem exists, but developers and researchers do not know that the problem exists. Perhaps it is known that there is a problem in general, but not exactly who is being affected or exactly how. Descriptive research can move a specific educational algorithm from unknown bias to *known bias.*

In known bias, it is now known that there is a problem, where it is occurring, and who is impacted. Our knowledge may still be incomplete, but it is sufficient to potentially take action. Once we know what the bias is, it becomes possible to move towards *fairness.* There is increasing understanding of the steps that can be taken to increase the fairness of algorithms, within the broader machine-learning community (Mehrabi et al., 2021[16]; Narayanan, 2018[78]). Although this work remains far from perfect, and debate is ongoing about the best methods (Kleinberg, Mullainathan and Raghavan, 2016[18]; Berk et al., 2018[52]), there is enough knowhow about addressing algorithmic bias that once we know a bias exists, we can take steps to fix it. Finally, increasing algorithmic fairness can be a step towards creating a world with *equity*, with equal opportunity for all learners – see (Holstein and Doroudi, 2022[79]).

Figure 9.1. The progression from the current situation to equity



Note: Authors' design.

Working towards equity necessarily implies determining where current technologies and pedagogies are today most unfair, and working to fix these problems first. Many of these places of greatest unfairness involve inequities that are already widely known. But some may also be less well-known to the educational and policy communities. We may miss key inequities due to our own biases and assumptions. In other words, more research is needed, because the world of education today is mostly in a state of *unknown bias.*

Obstacles to fairness

There are currently many obstacles to achieving fairness and equity with educational technology. The biggest, as the previous section notes, is how much we do not know about the biases that exist in the world, in general but also between countries. As Baker and Hawn (2022[24]) note, unknown biases can be split into two categories. The first is when we do not know that algorithmic bias exists for a specific group of learners. The second is when we know that there is bias impacting a specific group, but we do not know how this bias manifests. Both types of bias appear to exist in our current understanding of algorithmic bias in education. The research thus far is limited, both in terms of what groups have been studied, and how thoroughly we have studied algorithmic bias in education for the groups it is known to impact. Even for relatively thoroughly studied problems such as racism and sexism, we do not know all the ways that racism and sexism impact the effectiveness of educational algorithms. The biases of educational algorithms for indigenous populations has been much less studied than the biases for other groups, for instance; transgendered learners have been much less studied; and the experience of racial minorities with educational algorithms has been much more thoroughly studied in the United States than in other countries.

One of the key barriers to conducting this type of research is the lack of high-quality and easily accessible educational data on group membership, identity, perception, or status. As Belitz et al. (2022[25]) notes, even when identity data is collected, it is in terms of a small number of categories. And most studies do not obtain even this limited level of identity or group membership data.

Barriers to collecting data on group membership come for many reasons, including convenience, regulatory barriers, and concerns around student privacy. Often, compliance organisations such as privacy officers and institutional review boards consider demographic data to be high-risk and create incentives (not always consciously) to avoid collecting this type of data. If – to give an example commonly seen in the United States – a researcher is required to collect parental consent if they collect demographic data, but is not required to collect any consent at all if they avoid demographic data, then there is a strong incentive to avoid collecting demographic data, and in turn to ignore issues of algorithmic bias (and other forms of bias as well). There are current efforts in many countries to create stricter data privacy laws for education – laws that have the goal of protecting children, but as currently designed may make it impossible to identify or address algorithmic bias (see discussion in Baker, in press).

Another key incentive that reduces investigation into algorithmic bias is the risk involved to any commercial organisation that is open about the flaws in their product. Any openness about a product's flaws – or even openness about a product's design – can be an opportunity for their competitors. An environment where commercial companies can choose whether or not to analyse their product's flaws, and where there is significant competition, is an environment where companies will have a strong reason not to look into (and fix) biases in their product. Being too open about bias may not just lead to sales competition – it may lead to criticism by journalists, community members, and academics. At the extreme, an organisation that is public about bias in their content risks lawsuits or action by regulators.

While there is currently some incentive to learning systems to demonstrate educational effectiveness – see platforms such as the What Works Clearinghouse and Evidence for ESSA (WWC, 2012[80]; Slavin, 2020[81]), currently these initiatives treat a curriculum as either effective or ineffective, rather than being effective or ineffective for specific groups of learners.

Another important obstacle to addressing algorithmic bias in education is the lack of toolkits for assessing and fixing algorithmic bias that are specifically tailored to education. Educational data has been known to be different than other types of data commonly used in machine-learning, possessing a complex multi-level nature (actions within students within classrooms within teachers within schools within districts; and identity factors that are confounded with those levels) that must be accounted for in order for an analysis to be valid (O'Connell and McCoach, 2008[82]). While existing toolkits are applicable up to a point, more work is needed to make it easy for them to be adapted and used in education – see (Kizilcec and Lee, 2022[38]; Holstein and Doroudi, 2022[79]). Existing toolkits for identifying algorithmic bias offer generally useful metrics (discussed above), but often ignore the unique aspects of educational data, making them less relevant. The reason is that existing toolkits for addressing algorithmic bias are designed to treat data points as interchangeable, and therefore are not compatible with educational algorithms that explicitly consider the multi-level nature of educational data. The lack of toolkits currently increases the cost of testing for and resolving algorithmic bias for organisations without expertise in this area.

All in all, then, while the importance of addressing algorithmic bias in education is clear, without concerted efforts there are also manifestly several challenges and obstacles which will slow efforts in this area. Fortunately, there are several steps which policy makers can take.

Recommendations for policy makers

In this section, we present six recommendations for policy makers that can help to address algorithmic bias, resolving or working around the challenges currently present in the environment, and building on existing work by academics, NGOs, and industry (Box 9.2).

Box 9.2. Six policy pointers for policy makers

1. Consider algorithmic bias when considering privacy policy and mandates so that privacy requirements do not prevent researchers from identifying and addressing algorithmic bias.
2. Require algorithmic bias analyses, including requiring necessary data collection.
3. Guide algorithmic bias analysis based on local context and local equity concerns.
4. Fund research into unknown biases around the world.
5. Fund development of toolkits for algorithmic bias in education.
6. Re-design effectiveness clearinghouses to consider learner diversity.

1. Consider algorithmic bias when considering privacy policy and mandates

The first recommendation is simply to not make it impossible to address algorithmic bias. As mentioned above, many countries are currently considering legislation around data privacy in education that would make it impossible to collect (or retain for sufficient time to conduct analysis) the data on student identity, interaction, and outcomes which is necessary to identify and address algorithmic bias. If educational technology providers cannot collect or cannot use data on learner identity, they cannot determine who is negatively impacted by algorithmic bias, and almost certainly cannot produce algorithms less impacted by algorithmic bias. If educational technology providers cannot retain data on student usage long enough to measure relevant outcomes, they cannot know if students in different groups are being differentially impacted. Student privacy is important but so is fairness.

2. Require algorithmic bias analyses, including requiring necessary data collection

Ideally, rather than create policy preventing the collection of data necessary to check for and address algorithmic bias, policy makers would require the collection of data needed for these purposes, under best-practices safeguards. Ideally, this data collection mandate would be combined with some degree of protection or release from liability for companies that fully followed required security practices (especially in today’s environment, where maintaining perfect data security is challenging even when following best practices).

This would be the first step towards requiring educational algorithms used beyond a certain scale (perhaps 1 000 active users) to explicitly document and publish checks for algorithmic bias, at minimum providing evidence on whether the models have substantial difference in their quality of performance for different populations (if present in their user base). The requirement to publicly release evidence on algorithmic bias would probably be sufficient to create strong pressure to fix biases found in the algorithms.

3. Guide algorithmic bias analysis based on local context and local equity concerns

One current challenge faced by organisations making good-faith attempts to collect data to investigate algorithmic bias is deciding which identity variables to collect data on (Belitz et al., 2022[25]). Policy makers can assist with this. While census categories provide one source of possible variables, census categories simultaneously miss key categories shown to be associated with algorithmic bias (as discussed above) and also can include groups not present in a specific data set due to uneven distribution of that group across the general population. Policy standardising a minimum set of identity markers to collect and report on in each policy region would provide consistency and comparability between different reports of algorithmic bias. It would also help to ensure that groups currently most disadvantaged in each region are supported rather than further disadvantaged by educational algorithms. Finally, standardizing on a minimum set of identity categories would also prevent organisations from reporting only the groups for whom their tool is unbiased. The actual process of selecting which categories are relevant within a specific policy environment should not be arbitrary; ideally, selection would be made by a representative combination of stakeholders in the local community, including researchers who can evaluate the data available.

4. Fund research into unknown biases around the world

As the discussion above illustrates, it is difficult to fix a problem if we do not know if it is there; it is difficult to fix *unknown biases.* Thus far, the super-majority of research on algorithmic bias has involved race/ethnicity and gender in the United States – and even in the United States, key racial or ethnic groups more represented in specific geographical areas (such as Native Americans, and members of the Portuguese and Brazilian diasporas in New England) have been under-studied, as have other categories connected to algorithmic bias.

Outside the United States, there has been much less research into algorithmic bias. There is a clear need for further research on algorithmic bias in education in other OECD countries, investigating which groups are impacted and how they are impacted. Without this research, developers around the world will be limited to addressing the inequity problems known to exist in the United States, which are different from the problems in other countries (Wimmer, 2017[83]), or will be guided by intuition rather than data in which problems they attempt to address.

Policy makers can address this current limitation by creating grant-making programs which make funds available for research into who is impacted by algorithmic bias in education in their region.

5. Fund development of toolkits for algorithmic bias in education

As discussed above, the current lack of good toolkits for identifying and addressing algorithmic bias in education raises the cost of doing so; an organisation must either hire an expert in this area or develop their own expertise over time. The development of high-quality, usability-engineered toolkits supporting the use of best practices will increase the feasibility of conducting this type of analysis and improvement, for a wide range of educational technology providers and researchers. Policy makers can address this limitation by creating grant-making programs which make funds available for the development of toolkits of this nature. Even one such toolkit would make a substantial difference to the field.

6. Re-design effectiveness clearinghouses to consider learner diversity

Currently, effectiveness clearinghouses such as the What Works Clearinghouse and Evidence for ESSA – created (respectively) directly by a governmental agency and with foundation grant funding – summarise the evidence for the effectiveness of different curricula, including computer-delivered curricula. However, they treat effectiveness as a single dimension – either a curriculum is effective for all or for none. Curricula and educational technologies may, however, be effective for specific groups of learners and not for others (Cheung and Slavin, 2013[84]). An educational technology that is algorithmically biased is unlikely to be equally effective for all learners; if its algorithms function less effectively for specific groups of learners, the technology is very likely to function less effectively at supporting those learners in achieving better outcomes. As new clearinghouses are developed, or existing clearinghouses seek future funding, it may be possible for policy makers to influence their directions towards considering differences between groups of learners in effectiveness. Doing so will provide greater incentive for educational technology providers (and curriculum developers in general) to document (and attend to) the effectiveness of their products for the full diversity of learners.

Conclusion

In this chapter, we have reviewed the current evidence for algorithmic bias in education: who is impacted, how they are impacted, and the (large) gaps in the field's understanding of this area. We review some of the factors slowing progress in this area, and conclude with recommendations for what policy makers can do to support the field in understanding and reducing algorithmic biases in education.

The potential of algorithms for education is high. The best adaptive learning systems and at-risk prediction systems have made large positive impacts on student outcomes (Ma et al., 2014[85]; VanLehn, 2011[86]; Millron, Malcom and Kil, 2014[87]). However, this potential cannot be fully reached if algorithms replicate or even magnify the biases occurring in societies around the world. It is only by researching and resolving algorithmic bias that we can develop educational technologies that reach their full potential, and in turn support every student in achieving their own full potential.

Policy makers around the world are at a key moment in the progress towards resolving algorithmic bias and developing educational technologies that are fair and equitable for all learners. There is increased understanding that algorithmic bias exists, including in education. There are the beginnings of progress in understanding who is impacted and how. However, this progress is limited in scope – specific dimensions of student identity (particularly race/ethnicity and gender) have been much more heavily studied than other dimensions which also appear to be affected by algorithmic bias. Furthermore, research on algorithmic bias in education has been heavily concentrated in the United States, creating a lack of clarity on who is being negatively impacted in the rest of the world, and how to support them. Finally, this progress is put at risk by the possibility of imbalanced privacy laws, which may prevent future work to investigate and fix algorithmic biases and, ultimately, enhance equity.

References

Anderson, H., A. Boodhwani and R. Baker (2019), *Assessing the Fairness of Graduation Predictions*. [50]

Angwin, J.; J. Larson; S. Mattu and L. Kirchner (2016), *Machine Bias*, Auerbach Publications. [4]

Baker, R. (2022), *The Current Trade-off Between Privacy and Equity in Educational Technology*, Rowman & Littlefield. [37]

Baker, R., A. Berning and S. Gowda (2020), *Differentiating Military-Connected and Non-Military-Connected Students: Predictors of Graduation and SAT Score*. [39]

Baker, R. and A. Hawn (2022), "Algorithmic Bias in Education", *International Journal of Artificial Intelligence in Education*, Vol. 32/4, pp. 1052-1092. [24]

Baker, R.; E. Walker; A. Ogan and M. Madaio (2019), "Culture in Computer-Based Learning Systems: Challenges and Opportunities", *Computer-Based Learning in Context*, Vol. 1/1, pp. 1-13, https://doi.org/10.35542/osf.io/ad39g. [62]

Barocas, S., M. Hardt and A. Narayanan (2019), *Fairness and Machine Learning. Limitations and opportunities*, https://fairmlbook.org/. [42]

Belitz, C.; J. Ocumpaugh; S. Ritter; R. Baker; S. Fancsali and N. Bosch (2022), "Constructing categories: Moving beyond protected classes in algorithmic fairness", *Journal of the Association for Information Science and Technology*, pp. 1-6, https://doi.org/10.1002/asi.24643. [25]

Berk, R., H. Heidari; S. Jabbari; M. Kearns and A. Roth (2018), “Fairness in Criminal Justice Risk Assessments: The State of the Art”, *Sociological Methods & Research*, Vol. 50/1, pp. 3-44, https://doi.org/10.1177/0049124118782533. [52]

Bireda, M. (2002), *Eliminating Racial Profiling in School Discipline: Cultures in Conflict*, Rowman & Littlefield Education. [49]

Blodgett, S.; S. Barocas; H. Daumé III and H. Wallach (2020), “Language (Technology) is Power: A Critical Survey of “Bias” in NLP”, *Proceedings of the 58th Annual Meeting of the Association for Computational Linguistics*, pp. 5454–5476, https://doi.org/10.18653/v1/2020.acl-main.485. [27]

Bridgeman, B., C. Trapani and Y. Attali (2012), “Comparison of Human and Machine Scoring of Essays: Differences by Gender, Ethnicity, and Country”, *Applied Measurement in Education*, Vol. 25/1, pp. 27-40, https://doi.org/10.1080/08957347.2012.635502. [21]

Bridgeman, B., C. Trapani and Y. Attali (2009), *Considering Fairness and Validity in Evaluating Automated Scoring*. [8]

Caton, S. and C. Haas (2020), “Fairness in Machine Learning: A Survey”, *arXiv preprint arXiv:2010.04053*, https://doi.org/10.48550/arXiv.2010.04053. [15]

Cheung, A. and R. Slavin (2013), “The effectiveness of educational technology applications for enhancing mathematics achievement in K-12 classrooms: A meta-analysis”, *Educational Research Review*, Vol. 9, pp. 88-113, https://doi.org/10.1016/j.edurev.2013.01.001. [84]

Chouldechova, A. (2017), “Fair Prediction with Disparate Impact: A Study of Bias in Recidivism Prediction Instruments”, *Big Data*, Vol. 5/2, pp. 153-163, https://doi.org/10.1089/big.2016.0047. [51]

Christie, S.; D. Jarratt; L. Olson and T. Taijala (2019), “Machine-Learned School Dropout Early Warning at Scale”, *International Educational Data Mining Society (EDM 2019)*, pp. 726-731. [22]

Corbett-Davies, S. and S. Goel (2018), “The Measure and Mismeasure of Fairness: A Critical Review of Fair Machine Learning”, *arXiv*, https://doi.org/10.48550/arXiv.1808.00023. [63]

Cramer, H. et al. (2019), *Translation Tutorial: Challenges of incorporating algorithmic fairness*. [46]

Crawford, K. (2017), *The Trouble with Bias - NIPS 2017 Keynote*, https://www.youtube.com/watch?v=fMym_BKWQzk. [26]

Darlington, R. (1971), “Another look at “cultural fairness.””, *Journal of Educational Measurement*, Vol. 8/2, pp. 71–82, https://doi.org/10.1111/j.1745-3984.1971.tb00908.x. [53]

Digital Promise (2022), *Prioritizing Racial Equity in AI Design*, https://productcertifications.microcredentials.digitalpromise.org/explore/1-prioritizing-racial-equity-in-ai-design-4 (accessed on 23 December 2022). [20]

Dorans, N. (2010), “Misrepresentations in Unfair Treatment by Santelices and Wilson”, *Harvard Educational Review*, Vol. 80/3, pp. 404-413, https://doi.org/10.17763/haer.80.3.l253473353686748. [32]

Doroudi, S. and E. Brunskill (2019), *Fairer but Not Fair Enough On the Equitability of Knowledge Tracing*, https://doi.org/10.1145/3303772.3303838. [40]

Executive Office of the President (2014), *Big Data: Seizing Opportunities, Preserving Values*. [1]

Finkelstein, S.; E. Yarzebinski; C. Vaughn; A. Ogan and J. Cassell (2013), *The Effects of Culturally Congruent Educational Technologies on Student Achievement*. [35]

Friedman, B. and H. Nissenbaum (1996), “Bias in computer systems”, *ACM Transactions on Information Systems*, Vol. 14/3, pp. 330–347, https://doi.org/10.1145/230538.230561. [43]

Garcia, M. (2016), “Racist in the Machine: The Disturbing Implications of Algorithmic Bias”, *World Policy Journal*, Vol. 33/4, pp. 111-117, https://doi.org/10.1215/07402775-3813015. [7]

Gardner, J., C. Brooks and R. Baker (2019), *Evaluating the Fairness of Predictive Student Models Through Slicing Analysis*, Association for Computing Machinery, https://doi.org/10.1145/3303772.3303791. [29]

Green, B. (2020), *The false promise of risk assessments: epistemic reform and the limits of fairness*, https://doi.org/10.1145/3351095.3372869. [55]

Green, B. and L. Hu (2018), *The Myth in the Methodology: Towards a Recontextualization of Fairness in Machine Learning*. [56]

Green, B. and S. Viljoen (2020), *Algorithmic realism: expanding the boundaries of algorithmic thought*, https://doi.org/10.1145/3351095.3372840. [57]

Hellström, T., V. Dignum and S. Bensch (2020), *Bias in Machine Learning -- What is it Good for?*, https://doi.org/10.48550/arXiv.2004.00686. [44]

Holstein, K. and S. Doroudi (2022), *Equity and Artificial Intelligence in education*, Routledge. [79]

Holstein, K.; J. Wortman Vaughan; H. Daumé III; M. Dudik and H. Wallach (2019), *Improving fairness in machine learning systems: What do industry practitioners need?*. [61]

Hu, Q. and H. Rangwala (2020), *Towards Fair Educational Data Mining: A Case Study on Detecting At-risk Students*, https://files.eric.ed.gov/fulltext/ED608050.pdf. [12]

Kai, S. et al. (2017), *Predicting Student Retention from Behavior in an Online Orientation Course*. [66]

Kizilcec, R. and H. Lee (2022), *Algorithmic fairness in education*, Routledge. [38]

Klare, B., M. Burge; J. Klontz; R. Vorder Bruegge and A. Jain (2012), *Face Recognition Performance: Role of Demographic Information*, IEEE, https://doi.org/10.1109/TIFS.2012.2214212. [6]

Kleinberg, J., S. Mullainathan and M. Raghavan (2016), *Inherent Trade-Offs in the Fair Determination of Risk Scores*, https://doi.org/10.48550/arXiv.1609.05807. [18]

Kraiger, K. and J. Ford (1985), “A Meta-Analysis of Ratee Race Effects in Performance Ratings”, *Journal of Applied Psychology*, Vol. 70/1, pp. 56-65. [59]

Kung, C. and R. Yu (2020), *Interpretable Models Do Not Compromise Accuracy or Fairness in Predicting College Success*, Association for Computing Machinery, https://doi.org/10.1145/3386527.3406755. [13]

Lee, H. and R. Kizilcec (2020), *Evaluation of Fairness Trade-offs in Predicting Student Success*, https://doi.org/10.48550/arXiv.2007.00088. [19]

Li, X.; D. Song; M. Han; Y. Zhang and R. Kizilcec (2021), “On the limits of algorithmic prediction across the globe”, *arXiv preprint arXiv:2103*, https://doi.org/10.48550/arXiv.2103.15212. [64]

Loukina, A. and H. Buzick (2017), “Use of Automated Scoring in Spoken Language Assessments for Test Takers With Speech Impairments: Automated Scoring With Speech Impairments”, *ETS Research Report Series*, Vol. 3, https://doi.org/10.1002/ets2.12170. [76]

Loukina, A., N. Madnani and K. Zechner (2019), *The many dimensions of algorithmic fairness in educational applications*, Association for Computational Linguistics, https://doi.org/10.18653/v1/W19-4401. [11]

Makhlouf, K., S. Zhioua and C. Palamidessi (2021), “On the Applicability of Machine Learning Fairness Notions”, *ACM SIGKDD Explorations Newsletter*, Vol. 23, pp. 14-23. [54]

Ma, W.; O. Adesope; J. Nesbit and Q. Liu (2014), “Intelligent Tutoring Systems and Learning Outcomes: A Meta-Analysis”, *Journal of Educational Psychology*, Vol. 106/4, pp. 901-918. [85]

Mehrabi, N.; S. Zhioua and C. Palamidessi (2021), “A Survey on Bias and Fairness in Machine Learning”, *ACM Computing Surveys*, Vol. 54/6, pp. 1-35, https://doi.org/10.1145/3457607. [16]

Millron, M., L. Malcom and D. Kil (2014), “Insight and Action Analytics: Three Case Studies to Consider”, *Research & Practice in Assessment*, Vol. 9, pp. 70-29. [87]

Mitchell, S.; E. Potash; S. Barocas; A. D'Amour and K. Lum (2020), “Algorithmic Fairness: Choices, Assumptions, and Definitions”, *Annual Review of Statistics and Its Application*, Vol. 8, pp. 141-163, https://doi.org/10.1146/annurev-statistics-042720-125902. [30]

Naismith, B.; N. Han; A. Juffs; B. Hill and D. Zheng (2019), *Accurate Measurement of Lexical Sophistication with Reference to ESL Learner Data*. [75]

Narayanan, A. (2018), *Translation tutorial: 21 fairness definitions and their politics*. [78]

O’Neil, C. (2016), *Weapons of math destruction: how big data increases inequality and threatens democracy*, Crown Publishing. [2]

O’Reilly-Shah, V. et al. (2020), “Bias and ethical considerations in machine learning and the automation of perioperative risk assessment”, *British Journal of Anaesthesia*, Vol. 125/6, pp. 843-846, https://doi.org/10.1016/j.bja.2020.07.040. [5]

Obermeyer, Z.; B. Powers; C. Vogeli and S. Mullainathan (2019), “Dissecting racial bias in an algorithm used to manage the health of populations”, *Science*, Vol. 366/6464, pp. 447-453, https://doi.org/10.1126/science.aax2342. [31]

O’Connell, A. and D. McCoach (2008), *Multilevel modeling of educational data*, IAP. [82]

Ocumpaugh, J. and C. Heffernan (2014), “Population validity for educational data mining models: A case study in affect detection”, *British Journal of Educational Technology*, Vol. 45/3, pp. 487-501, https://doi.org/10.1111/bjet.12156. [9]

Ogan, A.; E. Walker; R. Baker; M. Rodrigo; J.C. Soriano and M.J. Castro (2015), “Towards understanding how to assess help-seeking behavior across cultures”, *International Journal of Artificial Intellignce in Education*, Vol. 25/2, pp. 229-248, https://doi.org/10.1007/s40593-014-0034-8. [65]

Okur, E.; S. Aslan; N. Alyuz; A. Arslan and R. Baker (2018), *Role of Socio-Cultural Differences in Labeling Students’ Affective States*, Springer International Publishing. [60]

Paquette, L.; J. Ocumpaugh; Z. Li; A. Andres and R. Baker (2020), “Who’s Learning? Using Demographics in EDM Research”, *Journal of Educational Data Mining*, Vol. 12/3, pp. 1–30, https://doi.org/10.5281/zenodo.4143612. [48]

Pardo, A. and G. Siemens (2014), “Ethical and privacy principles for learning analytics”, *British Journal of Educational Technology*, Vol. 45/3, pp. 438-450, https://doi.org/10.1111/bjet.12152. [36]

Penn Center for Learning Analytics (n.d.), *Algorithmic Bias in Education*, https://www.pcla.wiki/index.php/Algorithmic_Bias_in_Education. [69]

Ramineni, C. and D. Williamson (2018), “Understanding Mean Score Differences Between the e-rater® Automated Scoring Engine and Humans for Demographically Based Groups in the GRE® General Test”, *ETS Research Report Series*, Vol. 2018/1, pp. 1-31, https://doi.org/10.1002/ets2.12192. [68]

Riazy, S., K. Simbeck and V. Schreck (2020), *Fairness in Learning Analytics: Student At-risk Prediction in Virtual Learning Environments*, https://doi.org/10.5220/0009324100150025. [70]

Rzepka, N.; K. Simbeck; H. Müller and N. Pinkwart (2022), *Fairness of In-session Dropout Prediction*, https://doi.org/10.5220/0010962100003182. [71]

Samei, B.; A. Olney; S. Kelly; M. Nystrand; S. D'Mello; N. Blanchard and A. Greasser (2015), *Modeling Classroom Discourse: Do Models That Predict Dialogic Instruction Properties Generalize across Populations?*. [77]

Santelices, M. and M. Wilson (2010), “Unfair Treatment? The Case of Freedle, the SAT, and the Standardization Approach to Differential Item Functioning”, *Harvard Educational Review*, Vol. 80/1, pp. 106-134, https://doi.org/10.17763/haer.80.1.j94675w001329270. [33]

Sha, L.; M. Raković; A. Das; D. Gašević and G. Chen (2022), ““Leveraging Class Balancing Techniques to Alleviate Algorithmic Bias for Predictive Tasks in Education”, *IEEE Transactions on Learning Technologies*, Vol. 15/4, pp. 481-492, https://doi.org/10.1109/TLT.2022.3196278. [74]

Sha, L.; M. Raković; A. Whitelock-Wainwright; D. Carroll; V. Yew; D. Gašević and G. Chen (2021), *Assessing algorithmic fairness in automatic classifiers of educational forum posts*, https://doi.org/10.1007/978-3-030-78292-4_31. [73]

Silva, S. and M. Kenney (2019), “Algorithms, Platforms, and Ethnic Bias”, *Communications of the ACM*, Vol. 62/11, pp. 37-39, https://doi.org/10.1145/3318157. [45]

Slavin, R. (2020), “How evidence-based reform will transform research and practice in education”, *Educational Psychologist*, Vol. 55/1, pp. 21-31, https://doi.org/10.1080/00461520.2019.1611432. [81]

Soundarajan, S. and D. Clausen (2018), *Equal Protection Under the Algorithm : A Legal-Inspired Framework for Identifying Discrimination in Machine Learning*. [41]

Suresh, H. and J. Guttag (2021), “A Framework for Understanding Sources of Harm throughout the Machine Learning Life Cycle”, *EAAMO ’21: Equity and Access in Algorithms, Mechanisms, and Optimization* 17, pp. 1-9, https://doi.org/10.1145/3465416.3483305. [28]

Sweeney, L. (2013), “Discrimination in online ad delivery”, *Communications of the ACM*, Vol. 56/5, pp. 44-54, https://doi.org/10.1145/2447976.2447990. [34]

Tempelaar, D., B. Rienties and Q. Nguyen (2020), “Subjective data, objective data and the role of bias in predictive modelling: Lessons from a dispositional learning analytics application”, *Plos One*, Vol. 15/6, https://doi.org/10.1371/journal.pone.0233977. [58]

VanLehn, K. (2011), “The relative effectiveness of human tutoring, intelligent tutoring systems, and other tutoring systems”, *Educational Psychologist*, Vol. 46/4, pp. 197-221, https://doi.org/10.1080/00461520.2011.611369. [86]

Vasquez Verdugo, J.; X. Gitiaux; C. Ortega and H. Rangwala (2022), *FairEd: A Systematic Fairness Analysis Approach Applied in a Higher Educational Context*, https://doi.org/10.1145/3506860.3506902. [72]

Verma, S. and J. Rubin (2018), *Fairness Definitions Explained*, https://doi.org/10.1145/3194770.3194776. [17]

Wang, Z., K. Zechner and Y. Sun (2018), “Monitoring the Performance of Human and Automated Scores for Spoken Responses”, *Language Testing*, Vol. 35/1, pp. 101-120, https://doi.org/10.1177/0265532216679451. [10]

Wimmer, A. (2017), “Power and pride: national identity and ethnopolitical inequality around the world”, *World Politics*, Vol. 69/4, pp. 605-639, https://doi.org/10.1017/S0043887117000120. [83]

Wolff, A.; Z. Zdrahal; A. Nikolov and M. Pantucek (2013), *Improving retention: predicting at-risk students by analysing clicking behaviour in a virtual learning environment*, https://doi.org/10.1145/2460296.2460324. [47]

WWC (2012), *What Works Clearinghouse*, https://ies.ed.gov/ncee/wwc/. [80]

Yu, R., H. Lee and R. Kizilcec (2021), *Should College Dropout Prediction Models Include Protected Attributes?*, https://doi.org/10.48550/arXiv.2103.15237. [67]

Yu, R.; Q. Li; C. Fischer; S. Doroudi and D. Xu (2020), *Towards Accurate and Fair Prediction of College Success: Evaluating Different Sources of Student Data*. [14]

Zhang, J.; J.L. Andres, Juliana Ma; S. Hutt; R. Baker; J. Ocumpaugh; C. Mills; J. Brooks; S. Sethuraman and T. Young (2022), *Detecting SMART Model Cognitive Operations in Mathematical Problem-Solving Process*. [23]

Zuiderveen Borgesius, F. (2018), *Discrimination, artificial intelligence, and algorithmic decision-making*, Council of Europe, https://pure.uva.nl/ws/files/42473478/32226549.pdf. [3]

10 Emerging governance of generative AI in education

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This chapter gives an overview of 18 countries' governance of generative AI in education. Taking stock of the recent developments and massive uptake of generative AI tools across sectors, it examines countries and jurisdictions' nascent attempts at governing, encouraging, or restricting their use in education. It further compares current and upcoming regulatory framework and guidance with the uses that teachers and students make of generative AI tools in practice. Analysing countries and jurisdictions' policy priorities on the topic, it concludes by providing policy makers with a set of recommendations to consider moving towards adaptive and effective integration of generative AI tools in education.

Introduction

As digital technology and the use of smart data transform countries' education systems, the integration of artificial intelligence (AI) tools in education emerges as a pivotal focal point in reshaping instruction practices (OECD, 2021[1]). The emergence of generative AI has made the power of artificial intelligence visible to all and led to unprecedented debates about AI in the classroom. Generative AI is a subset of artificial intelligence that encompasses diverse capabilities from the generation of text through to image, music, and video. It autonomously generates new content from prompts, possibly challenging conventional teaching and assessment practices, notably homework, educational assignments, and exams (Pons, 2023[2]). This transformative technology has the capacity to democratise autonomous learning experiences, but also challenges traditional skill acquisition. As such, the initial debates about AI in education were in terms of "cheating" and students not doing their assignments themselves, with the risk of a loss of learning. AI capabilities are improving at a faster pace than ever before. When integrated with other technological advancements, generative AI tools could make chatbots a greater part of the learning experience and could possibly redefine teaching and learning.

The rapid evolution of generative AI, apparent to the broader public in the successive versions of *ChatGPT* since December 2022, or with the sudden visibility of tools such as *Lensa-AI* or *Dall-E*, suggests an ongoing improvement in AI capabilities compared to human capacities (OECD, 2023[3]). Education systems are faced with the new challenge to harness generative AI's potential while navigating challenges such as algorithmic bias, cheating, plagiarism, skills attrition, and concerns related to privacy, data security, intellectual property infringements, and sometimes even sustainability. Although this is an emerging domain for which there is little experience, policy makers are starting to consider guiding and sometimes even regulating artificial intelligence.

This chapter delves into the guidance and regulatory approaches adopted by 18 OECD countries and jurisdictions in governing, encouraging, or restricting the use of generative AI tools in education. As of 2024, national and central governments have mainly published non-binding guidance.

In the absence of central regulation, decisions made at the school level by teachers and school leaders significantly influence whether and how generative AI is integrated into the schooling context. Outside of schools though, generative AI is just another digital service, and in practice anyone with an Internet connection can access and use such tools (with limitations when not with a paying subscription).

Countries and jurisdictions may seek to play a role in the uptake of this new technology in education, exploring the balance between improving learning outcomes for all, fostering technological advancements, and safeguarding ethical, privacy, and equity considerations. The potential of generative AI in education has prompted a critical examination, but its implications are still in the first stages of exploration. Ensuring its use is aligned with educational objectives while mitigating risks associated with privacy, security and algorithmic biases appears as a challenge for governments. Moreover, understanding the multifaceted nature of generative AI, which extends beyond conventional text generation to a spectrum of creative outputs, is essential.

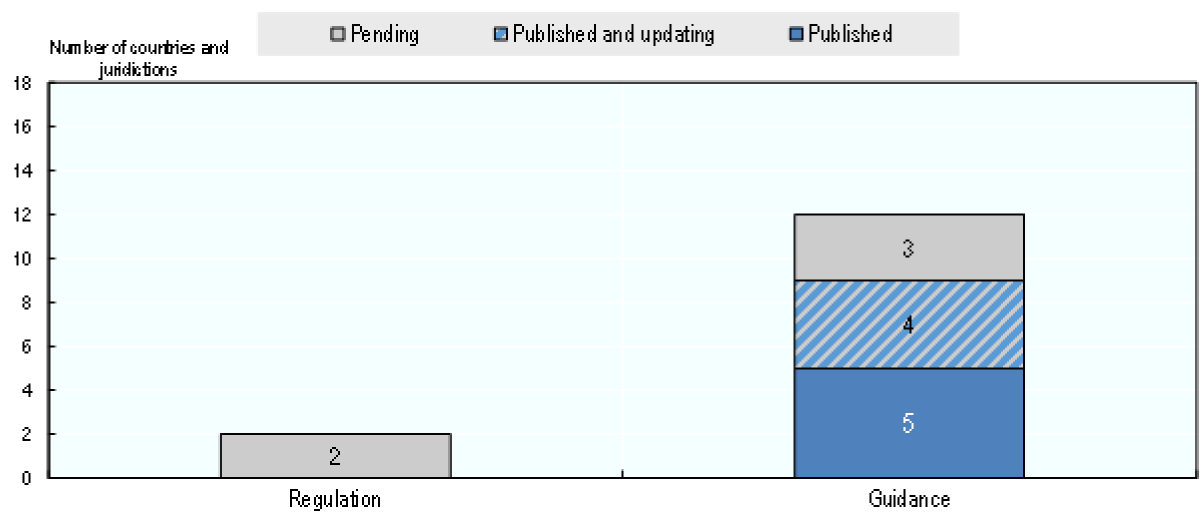
This chapter is organised as follows. First, it provides an overview of 18 OECD countries and jurisdictions' regulation and guidance on generative AI in education. Then, it examines how, regardless of existing or forthcoming guidance, schools, teachers, and students use generative AI in practice, in various educational contexts. The chapter then reports on countries and jurisdictions' policy priorities in the governance of generative AI in education. It concludes with a discussion on the benefits that countries and jurisdictions could reap from supporting an effective use of generative AI in education, outlining a set of policy recommendations in that direction.

Regulation and guidance

As of early 2024, none of the 18 countries and jurisdictions for which we have comparative information has issued a specific regulation on the use of generative AI in education (see Figure 10.1 and Table 10.1). Two countries, France and Korea, have proposed a regulation that awaits approval before implementation – noting that Korea's will be part of a broader "Artificial Intelligence Education Promotion Act", inclusive but not to limited to generative AI. Instead of, or waiting for, regulation, nine countries and jurisdictions (half of the respondents) have published non-binding guidance on the use of generative AI in education.

For instance, Japan issued *Temporary Guidelines for Use of Generative AI in Primary and Secondary Education* in 2023. The document contains guidance for schools and teachers on the general approach to take to make an appropriate use of generative AI in education and points to possible topics to be aware of when using it, such as protecting personal information, privacy, and copyright (see Box 10.1). Seven countries are drafting new or updated guidance on this topic.

Figure 10.1. Regulation and guidance on generative AI in education (2024)



Note: Among the nine countries that have published guidance, four (Czechia, Luxembourg, New Zealand, and England (United Kingdom)) are also preparing new or updating existing guidance as of 13 December 2023. N=18.

StatLink https://stat.link/91hyts

Table 10.1. Regulation and guidance on generative AI in education by countries and jurisdictions (2024)

	Regulation		Guidance (non-binding)		School responsibility
	Passed	Pending on approval	Published	Drafted and pending on approval	
Austria			✓		✓
Canada				✓	
Czechia			✓	✓	✓
Finland				✓	✓

France		✓		✓	
Hungary					
Iceland					✓
Japan			✓		
Korea		✓	✓		✓
Latvia			✓		
Luxembourg			✓	✓	
New Zealand			✓	✓	
Slovakia					✓
Spain					
Sweden					✓
Türkiye					
England (United Kingdom)			✓	✓	✓
Flemish Comm. (Belgium)			✓		✓
Total (18)	**0**	**2**	**9**	**7**	**9**

StatLink https://stat.link/ocgtk6

In nine countries and jurisdictions (half of respondents), schools are responsible for setting their own rules and providing guidance on the use of generative AI by their students, as long as they comply with broader national/central rules on data protection (see (OECD, 2023[4])). This is for instance the case in Nordic countries (Finland, Iceland and Sweden); as well as in Slovakia where the central government reports that local stakeholders are invited to integrate generate AI as they see fit in their schooling context.

Letting schools or lower levels of government enact their rules on AI in education does not prevent central governments from providing guidance though. In Czechia, the National Pedagogical Institute has released recommendations for school principals, teachers, students, and parents on how to use generative AI safely and effectively, based on instructions from the Ministry of Education, Youth and Sports. In addition, schools have their own sets of rules as agreed with their school boards, comprised of parent representatives, student representatives, teachers, and school leaders. In the near future, the Czech ministry plans to share guidance on AI that will include the design of a model curriculum integrating AI into project and research activities. Similarly, in the Flemish Community of Belgium, schools choose in full autonomy the learning tools they use. The community's Knowledge Centre provides specific guidelines for schools to use these types of tools in responsible manners though, as outlined by the Digisprong action plan.

Box 10.1. Examples of country guidelines on the use of generative AI in education

Japan's Temporary Guidelines for the Use of Generative AI in Primary and Secondary Education (2023)

Japan's approach to the integration of generative AI in education is outlined through a set of three objectives. First, schools are encouraged to initiate cautious use of generative AI, evaluating its impact, and addressing associated concerns such as privacy, security, and copyright issues. Second, schools are invited to reassert the importance of fact-checking and the development of information literacy, aligning with the evolving skills demand of the AI era. Third, Japan aims to promote the use of generative AI among teachers to reduce their (administrative) workload and to enhance their digital literacy, and in particular AI literacy.

Additionally, Japan stresses the importance of safeguarding personal information, advocating against the use of personal information for prompts and emphasising adherence to data protection laws. The guidelines feature information on information security, including cautions against exposing confidential information to external services. The document also addresses the complexities of copyright protection, urging schools to respect copyright terms and avoid infringement when using AI-generated materials.

Looking ahead, Japan outlines future measures, including the accumulation of knowledge through pilot measures and case study sharing. The country aims to support teacher training on AI by creating dedicated educational materials, including classroom videos. And in the longer run, the country will engage in a deeper revision of the modality of education in light of the widespread use of generative AI, exploring the changes it leads to in the skills needed for the future.

England's Policy Paper on Generative Artificial Intelligence (AI) in Education (2023)

In 2023, the English Department of Education's (DfE) released a policy paper that sets out the position of the government on the use of generative AI in education. It outlines both the limitations and benefits of using generative AI in education settings, clearly stating the education sector's objective to capitalise on the opportunities technology like AI presents as well as addressing its risks and challenges. This position paper was informed by a previous government's white paper that made the case for a "pro-innovation approach to AI regulation" and followed the establishment of a "Frontier AI Taskforce" for the United Kingdom who is tasked with evaluating risk at the frontier of AI.

The policy paper guides schools and colleges on the protection of personal and special category data. Moreover, it touches upon the use of intellectual property, prohibiting intellectual property from being used for training generative AI models without proper consent or copyright exemption. Emphasising cybersecurity, the policy encourages institutions to strengthen measures based on established cyber standards, recognising the potential for generative AI to enhance cyber-attack sophistication. Additionally, it highlights the need to prevent children from accessing harmful online content, pointing to the "Keeping Children Safe in Education" statutory guidance for comprehensive guidance on protective measures such as filtering and monitoring systems. For formal assessments, it points to the guidance from the Joint Council for Qualifications which reminds teachers and assessors of best practice in preventing and identifying potential malpractice, applying it in the context of AI use.

The department further expresses its continuous efforts in the future to collaborate with experts to address the implications of generative AI as an emerging technology, and to support schools to develop a knowledge-rich computing curriculum for children up to the age of 16.

United States: guidance published by states (2023)

In the United States, some states have released guidance on the use of generative AI in education. For example, the California Department of Education (CDE) has published a broader guidance on AI in education. CDE encourage educators to approach AI with an equity lens. In Oregon, the department of education has released an information note dedicated to generative AI in primary and secondary education. The guidance gives an overview of generative AI tools, their applications in education and the impacts they may have on equity and other issues (including bias, inaccuracy, plagiarism, copyright, access) and on student privacy. The guidance lists strategies to address or mitigate those risks while highlighting the vast potential of generative AI use in education, showcasing examples of opportunities in terms of learning design, teaching tool, instructional support, virtual assistance, student support and guidance, and future career options. The note concludes by informing school districts about things they should consider when developing their own strategies related to generative AI.

Source: Ministry of Education, Culture and Sports, Science and Technology Elementary and Secondary Education Bureau, Temporary Guidelines for Use of Generative AI in Primary and Secondary Education, 4 July 2023. / Department of Education, Generative artificial intelligence (AI) in education, 26 October, 2023 (Department for Education, 2023[5])/ California: https://www.cde.ca.gov/pd/ca/cs/aiincalifornia.asp/ Oregon: (Oregon Department of Education, 2023[6]).

Use beyond regulation and guidance

Regardless of regulation and guidance, all responding countries and jurisdictions noted that, in practice, generative AI is already used in schools (Table 10.2). Because of the specific guidance that they published on the topic, because of broader regulatory framework on the use of data and digital tools and resources in education, or because of devolved responsibilities in the governance of those new areas (down to teachers themselves), generative AI practices in the field may vary from one classroom to the other and from one context to the other.

Table 10.2. Use of generative AI in education: guidance and practices (2024)

Cases where use is covered by guidance (dark blue) or effective in practice (light blue)

	Use is allowed in schools	Only through school-approved or school-provided tools	Discouraged below a certain age	Encouraged for students	Encouraged for teachers	Allowed for homework assignments	Allowed in some exams
Austria	Yes, per guidance			Yes, per guidance	Yes, per guidance		
Canada	Yes, in practice						
Czechia	Yes, per guidance	Yes, in practice	Yes, per guidance	Yes, per guidance	Yes, per guidance	Yes, per guidance	
Finland	Yes, in practice			Yes, in practice	Yes, in practice	Yes, in practice	
France	Yes, per guidance		Yes, per guidance	Yes, per guidance	Yes, per guidance	Yes, in practice	
Hungary	Yes, in practice					Yes, in practice	No, in practice

	Use is allowed in schools	Only through school-approved or school-provided tools	Discouraged below a certain age	Encouraged for students	Encouraged for teachers	Allowed for homework assignments	Allowed in some exams
Iceland	Yes, in practice	Yes, per broader guidance	Yes, broader per guidance				
Japan	Yes, per guidance	Yes, per guidance	Yes, per guidance		Yes, per guidance		
Korea	Yes, per guidance	Yes, per guidance	Yes, per guidance	Yes, per guidance	Yes, per guidance	Yes, per guidance	
Latvia	Yes, per guidance			Yes, in practice	Yes, per guidance	Yes, in practice	No, per broader guidance
Luxembourg	Yes, in practice		Yes, in practice		Yes, in practice		No, per broader guidance
New Zealand	Yes, per guidance		Yes, per guidance				
Slovakia	Yes, per guidance	Yes, in practice			Yes, in practice	Yes, in practice	
Spain	Yes, in practice	Yes, in practice	Yes, in practice	Yes, in practice	Yes, in practice	Yes, in practice	Yes, in practice
Sweden	Yes, in practice	Yes, per broader guidance	Yes, in practice			No, per broader guidance	
Türkiye	Yes, in practice	Yes, in practice		Yes, in practice	Yes, in practice		No, in practice
England (United Kingdom)	Yes, per guidance						No, per broader guidance
Flemish Comm. (Belgium)	Yes, per guidance		Yes, per guidance	Yes, per guidance	Yes, per guidance	Yes, in practice	
Total (Yes, per guidance)	10	4	7	5	7	2	0
Total (Yes, in practice)	8	4	3	4	5	7	1
Total (Yes)	**18**	**8**	**10**	**9**	**12**	**9**	**1**

Note: The first total row indicates the number of countries and jurisdictions where specific guidance on generative AI in education recommends a certain use. The second total row indicates where this use is also prevalent in practice. Third total row sums both uses, whether they are part of a guidance or simply effective in practice. Some countries and jurisdictions have not yet published guidance on the use of generative AI education, but other pieces of their existing education regulation or guidance may cover the areas outlines here – marked as “broader guidance”.
Read: Five OECD countries and jurisdictions have guidance on generative AI that encourage students to use those tools, and four more are countries where this is the case in practice.

StatLink https://stat.link/nyecda

In some cases, countries' national/central guidance on generative AI aims to guide the use of such tools in schools. In 4 countries and jurisdictions out of 18 for which we have comparative information, guidance recommends that only approved generative AI tools should be used; and in seven countries and jurisdictions, it suggests that only students above a certain age should be using them, regulated per guidance. In fact, the latter restriction often corresponds to the tool's terms of use. For instance, OpenAI indicates that children under the age of 13 should not use *ChatGPT*, and that children under the age of 18 need the approval of their parents or guardians. As such, in their guidance, Japan and the Flemish Community of Belgium simply asks schools to abide by each tool's terms and services.

As of 2024, five central/national guidance explicitly encourage students to use generative AI as part of their schooling activities: Austria, Czechia, France, Korea, and the Flemish Community of Belgium. Those five countries, along with Japan and Latvia, also explicitly encourage teachers to use it. Albeit encouraged by the central government, Korea provinces will deliver their own guidelines on the use of generative AI in education.

Conversely, several countries and jurisdictions – sometimes the same as the ones encouraging the use – also wish to limit the use of generative AI in schools, to the extent possible. In practice though, there are only a few situations in which the use of generative AI is effectively prohibited by countries. Exams are one example, as illustrated by guidance in England (United Kingdom), Latvia and Luxembourg. Students taking high-stake exams generally do not have access to the Internet anyway. Only one country, Sweden, further forbid the use of generative AI for homework. This will require schools to be equipped with appropriate detection software, which is only rarely available yet.

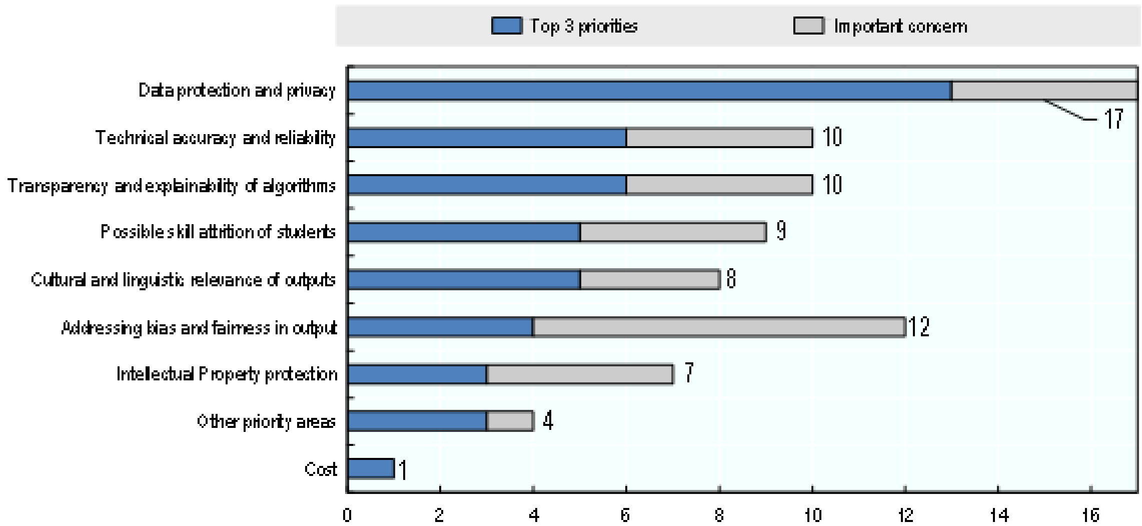
Japan's 2023 *Temporary Guidelines for Use of Generative AI in Primary and Secondary Education* provide schools and teachers with broad guidelines on the use of generative AI for written homework assignments. Teachers must advise students to refrain from using generative AI for graded tasks, reminding them about the concerns related to submitting AI-generated work instead of one's own original work. Moreover, teachers are encouraged to check students' work, verifying for instance if it is based on student's personal experience or if they understood the content learned. For non-graded assignments, Japan's *guidelines* specify that generative AI may be used if students verify their sources and acknowledge the use of a generative AI tool: the name of the generative AI tool used, as well as the prompts used, should be referenced.

In more than two thirds of the countries and jurisdictions (12 out of 17), teachers are encouraged, by guidance or in practice, to use generative AI in their classrooms. Specifically, seven countries provide training opportunities for teachers on the topic as part of their national/central guidance. The remaining five countries report that training is available in practice, possibly at lower levels of government. In Latvia, the ministry has developed a set of use cases in which generative AI can be used to assist teachers' work. Teachers can watch these examples on YouTube, via the government's channel. Similarly, the Swedish National Agency for Education prepares open webinars on the use of generative AI for teachers.

Policy priorities

Beyond questions about access and use of generative AI in education, countries and jurisdictions were asked about the key issues that were addressed in their education policy discussions. Seventeen of them expressed their policy priorities on the topic (Figure 10.2).

Figure 10.2. Priority issues regarding the regulation and guidance about generative AI in education (2024)



Note: Countries and jurisdictions could not select more than three "Top 3 priorities", and up to five answers in total. N=17.

StatLink https://stat.link/wh8oa5

First, all responding countries and jurisdictions highlighted data protection and privacy issues as one of their top three priorities (13) or as an important policy concern (4) regarding the use of generative AI in education (see Table 10.3). This is by far the policy area governments prioritise the most.

Second, countries and jurisdictions also prioritise the technical accuracy and reliability of generative AI, the transparency and explainability of algorithms, addressing bias to ensure fairness as well as the cultural and linguistic relevance of its outputs. With the exception of New Zealand, only non-English speaking countries prioritised the latter area.

A third body of policy priorities for countries and jurisdictions concerns possible skill attrition among students where generative AI is used. Whether as a top or secondary priority, nine countries have included this in their ongoing policy debates. In Sweden for instance, officials reported that identifying new skills and competences that students would need in the next 10 years was a crucial point in their ongoing discussions on AI in education.

Finally, concerns over the protection of intellectual property were also raised as a priority policy area, albeit to a lesser extent than the aspects mentioned above (seven countries and jurisdictions). They come just above concerns over the cost of generative AI tools, which are only brought forward in Hungary; and above other types of concern such as the equitable access and use of those digital tools in schools and at home, which threatens to amplify existing inequalities among students, as expressed in Czechia.

Table 10.3. Country priorities in generative AI regulation in education (2024)

	Data protection and privacy	Bias and fairness in output	Transparency and explainability of algorithms	Technical accuracy and reliability	Possible skill attrition	Cultural and linguistic relevance of output	Intellectual Property protection	Other (e.g., equity)	Cost
Austria	++	+	+		++	++			
Canada	++	++	++	+			+		
Czechia	++	+	+				++	++	
Finland	++	+	++		++	+			
France	++	++	++	+			+		
Hungary	++			++	+	+			++
Japan	+	+	+	+			+		
Korea	++	++	++						
Latvia	+			++	+	++	++		
Luxembourg	++	+			+	++	++		
New Zealand	++			++		++			
Slovakia	+		+	+	+				
Spain	++	++	++		++	+			
Sweden	+	+			++			++	
Türkiye	++			++		++		+	
England (United Kingdom)	++	+		++			+	++	
Flemish Comm. (Belgium)	++	+	++	++	++				
Total	**17**	**12**	**10**	**10**	**9**	**8**	**7**	**4**	**1**

Note: “Top 3 priorities” are marked with “++”, while “Other important concerns” are marked with “+”. Countries and jurisdictions could not select more than three “Top 3 priorities”, and up to five answers in total. N=17.

StatLink https://stat.link/ds2zx8

Discussion and policy recommendations

As of 2024, countries and jurisdictions do not formally regulate the use of generative AI in education. Instead, some of them have issued non-binding guidance specific to the use of those tools into teaching, learning and assessment practices. They also sometimes leave it to lower levels of governments, schools, and teachers themselves to decide whether and how to integrate generative AI into the schooling context, provided that the use complies with broader regulation on digital technology in education.

Moving forward, countries and jurisdictions may leverage different approaches to work on their guidance regarding generative AI in education. They may develop new guidance or update previous documents based on the lessons of actual uses within their countries, keeping an open mind as regards the multiple and diverse benefits that generative AI tools of all sorts (e.g., text, image, music, video generation) may bring to transform and improve education.

Provide guidance and keep regulatory framework adaptive. Countries should develop and disseminate clear guidelines for the use of generative AI in education. These guidelines should highlight and showcase the potential of generative AI in education to improve teaching and learning practices, while addressing issues such as algorithm bias, privacy, and data security. If regulatory frameworks are adopted, they should be adaptive and forward-looking, capable of accommodating the evolving landscape of generative AI. Instead of rigid restrictions, countries should adopt frameworks that provide guidance and oversight, allowing for innovation while safeguarding against potential risks and ensuring accountability. The "opportunities, guidelines and guardrails for effective and equitable use of AI in education" presented in chapter 16 provide countries with some guiding principles that apply to generative AI as well.

Promote dedicated teacher training programmes and cultivate stakeholders' digital literacy. Governments should encourage the integration of generative AI examples in teacher training programmes to enhance their digital literacy with generative AI tools. They could also propose some dedicated programmes, covering both the technical aspects but also the pedagogical and ethical considerations associated with the integration of AI in the educational environment. They could for example show how generative AI could be used to strengthen students' creativity or to develop their critical thinking. They should also highlight practices that should be discouraged, for example the use of generative AI to grade or provide feedback on students' work.

Encourage research and collaboration and monitor impact. Countries should encourage research on the uses of generative AI in the teaching and learning process. Establishing partnerships between education authorities, AI developers, and researchers could contribute to a better understanding of the benefits and challenges of the technology.

Facilitate the sharing of best practices and foster international collaboration. Nationally, governments could facilitate platforms for the exchange of information and best practices on the use of generative AI among educational institutions. This could also be done internationally.

References

Department for Education (2023), *Generative artificial intelligence (AI) in education*, https://www.gov.uk/government/publications/generative-artificial-intelligence-in-education/generative-artificial-intelligence-ai-in-education. [5]

OECD (2023), *Is Education Losing the Race with Technology?: AI's Progress in Maths and Reading*, Educational Research and Innovation, OECD Publishing, Paris, https://doi.org/10.1787/73105f99-en. [3]

OECD (2023), *OECD Digital Education Outlook 2023: Towards an Effective Digital Education Ecosystem*, OECD Publishing, Paris, https://doi.org/10.1787/c74f03de-en. [4]

OECD (2021), *OECD Digital Education Outlook 2021: Pushing the Frontiers with Artificial Intelligence, Blockchain and Robots*, OECD Publishing, Paris, https://doi.org/10.1787/589b283f-en. [1]

Oregon Department of Education (2023), *Generative Artificial Intelligence (AI) in K-12 Classrooms*, https://www.oregon.gov/ode/educator-resources/teachingcontent/Documents/ODE_Generative_Artificial_Intelligence_(AI)_in_K-12_Classrooms_2023.pdf. [6]

Pons, A. (2023), *Generative AI in the classroom: From hype to reality?*, https://one.oecd.org/document/EDU/EDPC(2023)11/en/pdf. [2]

11 Interoperability: unifying and maximising data reuse within digital education ecosystems

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This chapter highlights the importance of interoperability within a digital education ecosystem. Interoperability is the capacity to combine and use data from disparate digital tools with ease, coherence and efficiency. In the absence of interoperable digital tools, data linkage and sharing may be possible but become error prone and time and resource consuming tasks. The chapter presents the different dimensions of interoperability (semantic, technical, organisational and legal) before highlighting where countries stand and showcasing promising initiatives. It concludes by encouraging further efforts in this area.

Introduction

A digital ecosystem is composed of a variety of digital tools maintained by different agencies and companies: student information systems, admission management systems, digital assessment platforms, digital credential systems, learning management systems, content management systems, digital learning resources, etc. All these tolls have their specific functions, but in some cases the ability to link the information from these different systems easily would be of great value to inform educational decisions or change some educational processes. The benefits of digital solutions and of a digital transformation would be more tangible to education stakeholders if some information collected by different digital tools could be combined. The fragmentation of the digital education ecosystem comes from many reasons and is not a problem in and by itself. It often becomes a wasted opportunity because of a lack of interoperability between digital tools that would benefit from exchanging data with each other, thus making them available in real time to enrich or just allow data-driven decisions making. In other cases, the lack of interoperability leads to inefficiencies related to multiple data entry (when those are not intentional).

Interoperability is the capacity to combine and use data from disparate digital tools with ease, coherence and efficiency. In the absence of interoperable digital tools, data linkage and sharing may be possible but become error prone and time and resource consuming tasks. When the use of data requires manual or semi-automated data inputting and processing that consume staff time and energy on top of regular workloads, especially for teachers, data-related tasks will likely be perceived as tedious and alienating. By contrast, the adoption of interoperability solutions paves the way for an easier flow of data across systems with minimal effort and cost, allowing for efforts to focus instead on making actionable and innovative uses of data.

Importantly, the building blocks for developing more interoperable information systems in education exist already. Large investments in information technology (IT) equipment have made efficient tools for data collection and management widely available in education organisations across countries. And model standards for education data have been designed by a number of promising initiatives internationally. However, more comprehensive and strategic approaches are needed to achieve greater co-ordination in policy actions.

Ultimately, interoperability can contribute to unlocking the potential of education technology and data to support improvement and innovation in education. Interoperability is already a powerful engine for innovation in other sectors where it enables developments in open technology environments and incremental improvements of existing products and services, including user-driven innovations (Gasser and Palfrey, 2007[1]). This potential for innovation could also be leveraged more strategically in the education sector. Given the growing importance of digital technology in both formal and informal learning environments and the wealth of valuable data that sits dormant in disparate systems, interoperability can become a key enabler of more effective and personalised responses to learners and educators' needs (Fox et al., 2013[2]).

Layers of interoperability

Achieving interoperability within an education ecosystem requires a widespread adoption of technical and semantic standards, and eventually reducing organisational and legal barriers for data use and exchange.

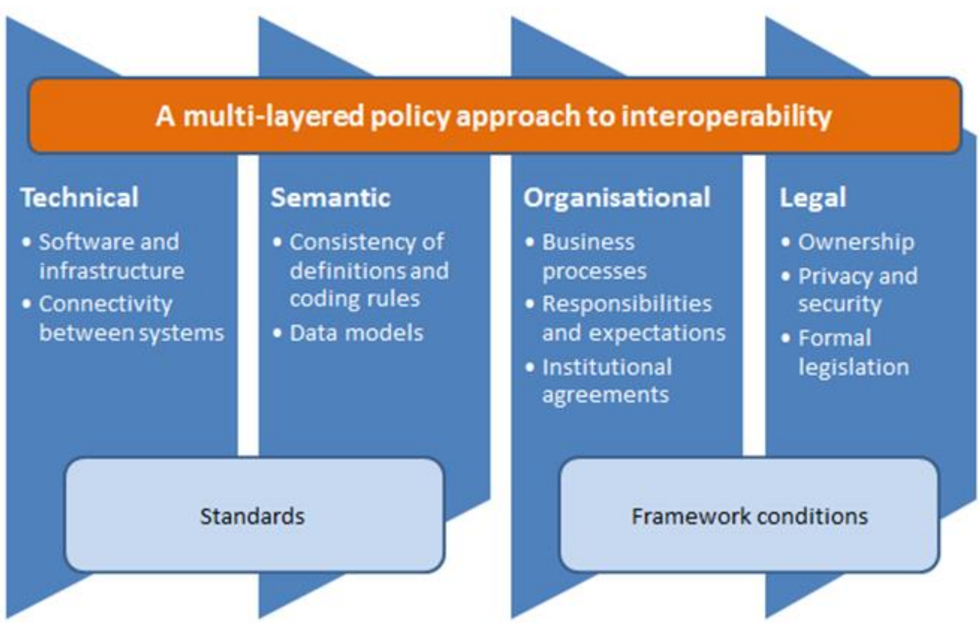
Interoperability increases the consistency and exchangeability of data collected and maintained by different systems. It reduces the need of ad-hoc processing to re-input, re-format or transform data, so that relevant information can be delivered in a more cost-effective and swift manner to support actions and decisions. At a system level, interoperability requires a widespread adoption of shared standards, including technical specifications for technology tools and applications, data definitions and code sets, and general models for system architecture. In some cases, it may also require a greater alignment in organisational processes and a legal framework supporting legitimate and innovative ways of using education data.

The goal of enhancing capacity to exchange data and sharing useful information for decision-making encompasses several dimensions, and interoperability initiatives may seek different points of entry into the data ecosystem. A useful tool to classify policy options is the conceptual model of the European Interoperability Framework (EIF), which supports the delivery of digital public services from an e-government perspective (European Commission, 2017[3]). The EIF identifies four layers of interoperability: technical, semantic, organisational, and legal. The distinction between multiple dimensions of interoperability is a shared feature with other frameworks and models for data standards (e.g. (Kubicek, Cimander and Scholl, 2011[4]); Redd (2012[5])) emphasises the notion that achieving interoperability goes beyond establishing a compatible technological infrastructure. A review of interoperability policy initiatives in e-government suggests a common two-phase interoperability roadmap where the design and adoption of standards precedes the alignment of organisational processes (Guijarro, 2007[6]).

Building on the EIF model, Figure 11.1 provides an illustration of the four dimensions of interoperability discussed in this chapter. First, the technical layer relates to IT applications and infrastructure linking data systems and services. Second, the semantic layer refers to the meaning of and relationships between different data elements. Third, the organisational layer concerns the alignment of business operations across organisations under a common understanding of the end-to-end data generation and use process. Lastly, the legal layer pertains to the coherence between the legal frameworks that regulate aspects such as data ownership, data security or privacy protection.

Data standards supporting interoperability correspond to the first two layers of the model – i.e. either technology specifications that enable communication between systems, or semantic standards that enable systems to understand the information that flows through them. In turn, the organisational and legal layers can be taken to represent the framework conditions for the successful implementation of interoperability initiatives at the system level.

Figure 11.1. A four-layered model for interoperability policies



Source: Adapted from the New European Interoperability Framework (European Commission, 2017[3]).

This chapter will be organised as follows. The next sections will be devoted to technical, semantic as well as organisational and legal interoperability. Beyond unpacking some aspects of the challenges for different types of resources, they will highlight a few country or international initiatives to address them. These sections provide examples of interoperability standards and products developed by different organisations for education, with no endorsement of the mentioned examples. Then we will present some of the policy and practices used by countries to improve interoperability of their digital ecosystem and conclude.

Technical interoperability

Technical interoperability is concerned with facilitating the communication between IT systems and services. Standards in the technical layer are specifications that guide the design of software applications and systems architecture more generally by defining common rules for transferring data and other forms of digital content.

In education, the need for technical interoperability stems to a large extent from the diversity of legacy IT tools employed by schools and universities to meet their operational needs in an increasingly digitalised environment. Most often, these tools were developed for concrete functions in specific institutional settings, and rarely with the objective of enabling interoperability with external tools. Nonetheless, the technical layer is arguably the most mature among the four dimensions of interoperability within this framework. Today, technology can be an enabler rather than a barrier to interoperability and a range of readily available technical standards provide components for building a more interoperable digital ecosystem in education.

The number of existing and emerging standards for technical interoperability in education is large and taxonomies evolve rapidly to encompass a growing diversity of solutions. For instance, Redd (2013[7]) and Fox (2013[2]) distinguished three broad categories of standards dealing mainly with content packaging formats and data exchange protocols, while a more recent taxonomy by CoSN (Consortium for School Networking) (CoSN, 2017[8]) identifies eight families of solutions. This reflects not only the fast pace of technological developments but also growing concerns around challenges such as privacy protection, which motivate, for instance, new solutions for identity management solutions in digital environments.

Content interoperability

A first major category of technical standards is that of solutions for making digital content interoperable. Their aim is to standardise packaging formats to enable the seamless transfer of learning content (e.g. text, video, graphics, assessments) across systems and thereby help students and teachers to have easier access to material scattered across different digital platforms (e.g. learning management systems, virtual learning environments, repositories of open educational resources), ideally with a mix-and-match functionality.

Examples of standards for content interoperability stem from specifications established by the 1EdTech (formerly the IMS Global Learning Consortium), a membership organisation of the educational technology (EdTech) industry. As of 2023 it had 932 member companies from 28 countries (including 85% of US companies). An example of the standards it offers is the Common Cartridge, a standardised way to import and export course materials across learning platforms by providing a template to represent digital course materials so that the content can be developed in one format and used on other learning systems. Related solutions for test items and other assessment materials are the Accessible Portable Item Protocol (APIP) standard and the Question & Test Interoperability (QTI) specification. Materials conformant to these standards can be transferred across item banks, test construction tools and assessment delivery systems. Another example is the Learning Tools Interoperability (LTI), which facilitates the integration of externally hosted rich learning applications such as virtual laboratories into other platforms without the need of custom solutions.

Data connectivity and integration

A second group of standards in the technical layer addresses data connectivity and integration. These standards define protocols for the process of requesting and sending data across databases, thus facilitating transfers between compliant solutions.

Data connectivity standards rely on "drivers" to access different databases and translate functions from one database language to another. Examples include Open Database Connectivity (ODBC), Java Database Connectivity (JDBC) or Object Linking and Embedding Database (OLE DB). Many industry actors, including Microsoft and Oracle, have developed standards in this category.

Data integration standards, in turn, seek to give users of a system a unified view of data residing in different sources without requiring the physical migration of the data. Data integration involves putting data into a common format and creating interfaces to enable simultaneous access and visualisation. Dashboards have become the most common form of data integration interfaces. By virtue of these applications, teachers can for instance visualise student rosters alongside assessment results, often supported by features such as colour coding and automated graphing. An example of this type of solution is the Analytics Middle Tier (AMT) developed by the Ed-Fi Alliance, which enable data analytics (or business intelligence – BI) on relational and normalised databases that avoid the duplication of data storage. This can for example allow educators to monitor student progress in real-time by combining key indicators of students' strengths and areas for improvement.

Identity management

A third group of technical standards provide solutions for identity management. This refers to the processes of identifying users upon log on to a system by means of some identifiers, passwords or other markers (authentication), and of establishing rights and rules to access the tools, resources and data available within the system (authorisation). Many of these standards enable checks regarding the identity, attributes and entitlements of the users of a given system or application, thus creating more secure conditions for accessing and sharing data. Examples of specifications in this category include the OpenID Connect (OIDC) authentication layer and the OAuth authorisation framework developed by the OpenID Foundation, or the Security Assertion Markup Language (SAML) of the Organization for the Advancement of Structured Information Standards Consortium (OASIS).

Student rostering

A fourth set of standards in the technical layer provide solutions for student rostering. Rosters remain the basic form of recording names of students and grouping them into specific classes, sections and programmes within schools. Rosters are often used as the reference lists for linking different types of data elements, from student assessment results to school registration records, and for managing access to learning content and other data. Automated rostering is less burdensome and error-prone than a manual recording process, but problems emerge when data within a roster cannot be transferred or read by other applications due to discrepancy in how student data are formatted or typed in. For instance, two different rosters may place student middle names in different fields, or deal differently with composite names or abbreviations. Rostering standards make it possible to automate the creation and sharing of rosters across compliant systems, thereby reducing data inputting and verification workloads for teachers and other school staff. Examples in this family of solutions include the OneRoster standard of the 1EdTech.

These four categories do not exhaust the list of existing technical standards with a direct application in the education sector. Other types of solutions with potential value for schools and education agencies include specifications for online portals, network infrastructure, digital accessibility or the search and tagging of digital educational resources (Fox et al., 2013[2]; CoSN, 2017[8]).

A sign of maturity of the technical layer of interoperability is the increasing development of technical standards in integrated suites of solutions that cover a wide range of applications while relying on a single technology package. Suites of products that have been designed to work together enhance the consistency of data flows across applications and enable an organisation-wide rather than a piecemeal transition to more interoperable information systems. The Ed-Fi Alliance and the Schools Interoperability Framework (SIF) are two leading organisations offering integrated sets of technical solutions for managing education data (Box 11.1).

Box 11.1. Integrated suites of technical standards

The Ed-Fi Technology

The Ed-Fi technology suite includes standards for the storage and exchange of student data as well as a set of supporting implementation tools. The technology was developed and is now owned and issued by the Ed-Fi Alliance, a non-profit organisation created in 2013 as a spin-off from the Michael & Susan Dell Foundation in the United States.

The Ed-Fi standards can support a broad range of scenarios dealing with student data, including exchanges of data between local and state-level information systems, the import of data from testing tools and other external services, or aggregation of data from different sources into a single platform. Among the solutions are an Operational Data Store (ODS) and multiple applications with the capacity to read and update data from and into the ODS. Classroom-level dashboards are another component of the Ed-Fi technology suite. The dashboards bring together browser-based collections of interactive charts, reports and visual indicators that give on-demand access to information about students. Dashboard views can be tailored for a variety of roles, including teacher, parent, principal, and district leader. Users can implement and customise dashboards in their existing technology environment using a starter kit with sample elements and key metrics.

The Ed-Fi data specification aligns with the Common Education Data Standards (CEDS) promoted by the United States Department of Education. The Ed-Fi Alliance is also collaborating with industry players such as 1EdTech with the aim to unify broader standards across the K-12 market in critical domains to include rostering, assessment and outcomes data.

The technology is vendor-neutral, open and built on widely adopted XML standards for ease of implementation. All solutions are available for use via free and perpetual licenses that provide unrestricted access and usage rights to the technology components as well as source code to facilitate further customisation.

Since its launching in 2011, the Ed-Fi technology has been adopted by a growing number of state education agencies, school districts and education service providers in the United States. As of June 2018, 30 states had licensed Ed-Fi technology, collectively representing over 30 million students and almost 2 million teachers.

Schools Interoperability Framework (SIF) Specifications by Access 4 Learning Community

The Schools/Systems Interoperability Framework (SIF) is a data sharing open specification used by academic institutions from kindergarten through workforce in Australia, New Zealand and the United States. The specifications are maintained by the Access 4 Learning Community (until 2015 the SIF Association), a non-profit organisation whose members include public education agencies, software vendors and other service providers in education markets.

The SIF Specifications are a set of platform-independent, vendor-neutral standards that enable software programmes from different companies to share information and interact, so that information systems at different levels can share data without any additional programming or adaptation.

Every SIF specification release consists of two major components. First, a data model that includes the set of XML and JSON schemas defining the formats of educational “objects” as they are exchanged between SIF-compliant applications. The second component is the infrastructure that defines the transport and messaging functionality for exchanging data, including XML schemas and OpenAPI specifications. In the different geographies where A4L operates, the SIF Specifications are aligned to existing local code sets and standards, including the Common Education Data Standards (CEDS) in the United States, and multiple standards from the Australian Bureau of Statistics in Australia.

Since 2017, all globally developed SIF Implementation Specifications are openly available under Creative Commons Attribution-ShareAlike International 4.0 (CC BY-SA) licenses.

SIF also promotes a certification programme in order to provide both end-users and vendors with quality assurance that products meet minimum performance standards to qualify for SIF certified status. A certification registry maintains a list of all SIF certified products.

Finally, Access 4 Learning has recently put more emphasis on privacy standards. Building on the Safer Technologies 4 Schools project in Australia, its Student Data Privacy Consortium (SDPC) has published an international education sector-specific data security standard that synthesises security, privacy and child safety requirements from across the United States, the United Kingdom, New Zealand and Australia.

Source: Ed-Fi Alliance website (http://www.ed-fi.org); Access 4 Learning Community website (www.A4L.org)

The benefits of technical interoperability are not limited to data management within a given country or jurisdiction but can also extend to improving international exchanges of education data and the compatibility of digital tools. Technical standards are one of the building blocks towards creating student information systems with the capacity to provide timely access to official statistical data from a variety of countries. Such systems require the use of globally agreed data models supported by high-quality metadata. As an example, the Statistical Data and Metadata eXchange (SDMX) is an initiative sponsored by international statistical organisations with the aim of improving the mechanisms and processes for the international exchange of statistical data and metadata.

Technical interoperability at the international level would also allow to broader the education technology market and potentially increase the quality of the available tools – and the incentives of the education technology developers. The widespread adoption of technical interoperability standards by educational organisations would be a critical enabler for a less fragmented digital ecosystem with an improved capacity of automating and accelerating data exchanges and reusing information gathered in one application to make another more effective and useful. Technical standards would also be key building blocks for next-generation education information systems that mash up administrative, learning and assessment data and interact with banks of digital educational resources (Vincent-Lancrin and González-Sancho, 2023[9]).

However, technical standards are not directly concerned with other aspects of data quality such as interpretability, relevance or consistency. For instance, data may flow easily across systems but still lack a common basis for interpretation. This is why technical solutions need to be aligned to semantic standards.

Semantic interoperability

Semantic interoperability relates to ensuring that the structure and meaning of data is preserved as the data flow across separate systems. Semantic standards are agreed-upon definitions of sector-specific sets of data elements and the relationship that exist between them. This involves, on the one hand, defining controlled vocabularies, thesauri, code lists or other forms of metadata in order to establish the meaning of data. On the other hand, it requires building data models, taxonomies or schemata to describe how entities and data elements relate logically to each other. A second objective is to make data more easily searchable and findable, for example when the data are digital learning resources. The section focuses on semantic interoperability in the case of administrative data and of digital learning resources.

Administrative data

The need for semantic interoperability stems from a lack of consistency in the rules that govern administrative data collection in schools and education agencies. While it is best to interpret data with regard to their original context, variation in terminology, coding and logical structure between data elements can often compromise the quality of the information that is shared across organisations. By setting a stable reference structure, semantic interoperability provides a basis for consistent interpretations of education data and improves the comparability of records maintained in different information systems. Conformance to semantic standards can also reduce the burden of data verification because, when content is unambiguously defined, organisations have a common ground for understanding the data that is being exchanged.

A case in hand is the academic record transcript that accompanies a student in the event of a school move or a transition between different levels of the education system. For the receiving institution, information on this transcript can be the basis for deciding whether to place the student on a given study track or grant the student financial aid. When transcripts are not standardised, it becomes difficult to act on information that may vary from one student to another in its content or meaning. As an example, in the United States the requirements for earning a high school diploma have varied widely across states, leading to multiple means of defining high school graduation. Different ways of determining what constitutes completion of secondary education can hinder the comparability of graduation rates calculated under different criteria, and thereby affect inferences about the factors associated with dropout and the effective targeting of resource allocation policies for schools (National Research Council, 2011[10]).

Among the key tools for achieving semantic interoperability are data dictionaries and logical data models. Dictionaries are repositories of descriptive information about data elements including their meaning, potential values, format, and ideally covering their origin and potential usage as well. These metadata describe data elements and explain the transformations they underwent (e.g. recoding) before reaching end users, thereby helping to streamline the understanding of education data.

Data models, in turn, are conceptual structures that catalogue the full set of data entities and data elements while specifying the relationships between them. The explicit formulation of a general underlying model brings benefits such as providing a conceptual skeleton to guide the design of data system architectures. Data models should be designed with the view that data should serve to addressing relevant policy and research questions. Clarity on the data models that would help support organisations' missions and operational needs can also be helpful for education leaders when selecting products and services in the market for data management tools, as well as to vendors in the process of designing data systems and related products (National Forum on Education Statistics, 2010[11]).

In the United States, a major initiative addressing the semantic layer of interoperability are the Common Education Data Standards (CEDS), a national collaborative effort initiated in 2009 to improve the quality of education data across the early learning through post-secondary and workforce environment (Box 11.2).

A central objective of the CEDS was to support stakeholders involved in the creation of state-wide longitudinal data systems.

At the international level, a reference set of standards in the semantic layer is the International Standard Classification of Education (ISCED). Maintained by the UNESCO Institute for Statistics (UIS) in consultation with member states and other international organisations such as the OECD, the ISCED framework classifies educational programmes and the resulting qualifications into internationally agreed categories. ISCED standards are used for assembling statistics on many different aspects of education of interest to policymakers and other users of international education statistics. Similarly, the European Skills/Competences, Qualifications, and Occupations (ESCO) classification developed by the European Commission provides a common reference terminology for labour market and the education and training sectors that seeks to bridge communication gaps and increase occupational and geographical mobility in the European Union. The international standards developed by the Data Documentation Initiative (DDI), which describe the data produced by surveys and other observational methods in the social, economic and health sciences, provides another example. It has been adopted by more than 30 large survey programmes and data archives globally since 2000. Among other applications, the standard allows to generate interactive codebooks, implement data catalogues and create concordance mappings across data collections.

The development of additional international standards allowing more granular comparative data elements within and across countries should be considered.

Box 11.2. The Common Education Data Standards (CEDS) in the United States

The Common Education Data Standards (CEDS) is a national initiative to develop common standards with the aim to streamline the exchange, comparison, and understanding of data within and across early learning through post-secondary and workforce institutions. CEDS is coordinated by the National Center for Education Statistics (NCES) with funding from the Department of Education and Institute of Education Sciences.

The CEDS have identified key data elements describing demographics, programme participation, course information, and other attributes of students and the education system, as well as elements needed for high school-to-post-secondary transcripts and high school feedback reports. Released in February 2023, Version 11 of CEDS includes over 1 700 data elements. The design of the standards is a collaborative process open to a wide range of stakeholders. The adoption of the standards is voluntary and does not necessarily involve using all the proposed elements. Instead, benefits can be realised from adopting a partial set of standards.

Among other applications, the CEDS have been used by 11 states participating in the Common Content Tagging Initiative to create a common dictionary of tags, values, and definitions for a shared and searchable collection of open digital educational resources. CEDS language was also the basis for matching education and workforce data elements from 10 states in the context of the Multistate Longitudinal Data Exchange (MLDE) project of the Western Interstate Commission for Higher Education (WICHE). CEDS are also intended to assist agencies in the process of developing their data systems. For example, CEDS have been utilised as a development tool by the Alaska Department of Education and Early Development (DEED) for aligning elements in their legacy data systems when building a new longitudinal information system.

Several web-based tools support stakeholders in using and integrating the CEDS into their work. For instance, the CEDS Align tool allows agencies and organisations to import or input their current data dictionaries, assess their degree of alignment with the standards and compare themselves with others. The CEDS Connect tool, in turn, facilitates identifying connections between CEDS data elements and practical uses of education data, for instance locating elements that can serve to answers policy questions, to calculate metrics and indicators, and to meet reporting requirement at the federal level.

Source: Common Education Data Standards (CEDS) website (http://ceds.ed.gov).

The importance of semantic standards holds throughout the entire data life cycle, from collection to transformation and release. A shared understanding of the information being requested is essential to guide data collection efforts, but also to help data users make sense of the data and produce consistent reports that different audiences can then interpret with confidence in the meaning of the information. Semantic standards can thus be particularly useful for discussions that involve multiple stakeholders coming to the table with varying levels of knowledge about the data generation process and about how data can be interpreted, from researchers to policy makers, educators and families. Semantic standards can indeed provide common ground on which to base important conversations that concern education stakeholders across the board, and which generally revolve around a core set of key data elements and metrics.

Digital learning resources

A second important use case for semantic interoperability lies in taxonomies to tag digital learning resources. The COVID-19 pandemic has highlighted that, beyond availability, digital learning resources should be easily searchable and findable. At the global level, this is often not the case. At the beginning of the pandemic, identifying and curating digital learning resources relevant to local curricula have mobilised many actors' energy (Vincent-Lancrin, Cobo Romaní and Reimers, 2022[12]).

This need for standardised metadata for learning objects have long been identified, and several initiatives have been undertaken. The use of standard criteria associated with standardised vocabularies aims to support the reusability of learning objects, to support their discoverability and to facilitate their interoperability, notably in the context of online learning management systems.

The Dublin Core is the first developed standard of metadata for digital resources: started in the mid-90s and maintained by the Dublin Core Metadata Initiative (DCMI): its set comprises 15 metadata elements; it was formalised in 2009 as an international standard (as ISO 15836) by the International Organization for Standardization (ISO). For example, the EPUB e-book format uses Dublin Core metadata to describe the file.

Starting from the Dublin Core, another initiative attempted to provide standardised information about learning resources specifically. The LOM (Learning Object Metadata) standard developed to describe learning resources was published by the Institute of Electrical and Electronics Engineers (IEEE) Standards Association in 2002 and updated several times. This data model, usually encoded in XML, is more controlled than the Dublin core: it comprises a hierarchy of elements, which all have sub-elements, and specified the value space and data types for these elements. At the first level, there are nine categories (description, purpose, etc.). The latest standard was published in 2020 (1484.12.1-2020). Several country application profiles have been developed over time, adapting the idea to their national context. This is for example the case in Australia and New Zealand (ANZ-LOM), France, Greece, Israel, the Netherlands, Norway, Spain, Sweden, Switzerland and the United Kingdom. Similarly, Estonia's national standard taxonomy, Estcore, is inspired by the LOM international standard but adapted to the needs of Estonia's national educational curriculum.

Most of these profiles are meant for the education sector, while some focus on higher education or vocational education and training. Mainly developed in the late 2000s, the extent to which governments and resource developers use these standards is not well documented. When analysing 29 open educational resource (OER) repositories hosted by German universities, Abdel-Qader, Saleh and

Tochtermann (2021[13]) found that 17% of the resources used the LOM standard. As an example, Box 11.3 presents how France uses a LOM-based standard for its school sector and what it requires in practice.

Box 11.3. The ScoLOMFR standard to describe learning resources in France

France started to develop a standardised taxonomy to describe digital learning resources in 2008. The French authorities adapted the LOM standard to the French context and turned it into the LOM-FR standard, which was formally published as a standard by the AFNOR (*Association française de normalisation*, the French Association of Standardisation) in 2006 (as NF Z76-040). This standard was then adapted for school education as ScoLOMFR (and for higher education as SupLOMFR). It is maintained by an agency of the ministry of education (*Réseau Canopé*) in charge of lifelong learning and teacher professional development.

The ScoLOMFR standard is made up of 9 categories, about 60 sub-categories, 40 controlled vocabularies defining French education levels and about 15 000 descriptive concepts. Digital learning resources are encoded through a given XML format and characterised by this common, pre-defined set of descriptors (e.g. type, interactivity level, typical age range, language, etc.), which facilitates teachers' (and students') search, consultation, use, and sharing of pedagogical resources. While documenting some of those elements is mandated, many sub-categories are just recommended or optional. Providing information about the pedagogical aspects and even subjects of the learning resources is just recommended.

One strength of the standard is to provide a description of the target audience (subject and level of the students for all possibilities in the French education system) – so that resources developed for a specific course (e.g. science for 10th grade students following a specific track). The French national curriculum is fully described based on the taxonomy and is updated every year to follow curricular evolutions. This also provides actors with an example of specification for the content of their resources. Finally, an online form supports the use of the tagging for resources developers.

The standard is developed for all developers of learning resources (from teachers to private publishers). While it is voluntary by nature, the ministry education mandates the tagging of all learning resources according to the ScoLOMFR standard in its procurement processes, thus providing a strong incentive to education publishers to use it.

Source: Réseau Canopé (https://www.reseau-canope.fr/scolomfr/)

Organisational and legal interoperability

The organisational and legal layers of interoperability represent framework conditions for the implementation of technical and semantic standards and, more generally, for the governance of data use. Legal regulations and organisational arrangements are broadly shared within most education systems, but in federal or devolved systems where jurisdictions with different mandates can coexist, developing more interoperable information systems may also require ensuring greater alignment in these areas.

The organisational interoperability layer is concerned with the alignment of business processes, responsibilities and expectation across organisations, with the aim of improving collaboration towards shared goals (European Commission, 2017[3]). For educational organisations, fostering a common understanding of the role that data exchanges and data use can play in achieving the shared goals of improving the quality and efficiency of the education system is an underlying mechanism for organisational alignment.

An important aspect of organisational interoperability in education is the standardisation of some of major operational processes of schools and universities. These processes are most often service-specific, including registering students, recording their outcomes, or hiring teachers. Interoperability is achieved when organisations across different jurisdictions implement standard procedures for these complex tasks. Service-oriented-architectures (SOA) provide a basis for achieving organisational interoperability. These architectures allow for the common description of inter-organisational processes and automated workflows, for instance by using standardised business process definition languages (Kubicek, Cimander and Scholl, 2011[4]). Another area of organisational interoperability relates to setting establishing formal agreements around data exchange and data use.

Box 11.4. The National Schools Interoperability Programme (NSIP) in Australia

Australia established its National Schools Interoperability Programme (NSIP) in July 2010 as a joint initiative of state, territory and federal education agencies to support the development of digital learning infrastructure in the education sector. Since 2019, it has become a business unit of Education Services Australia. NSIP works with public agencies and technology and service providers to develop solutions tailored to common data and digital content management problems in schools. The programme encourages the use of data standards and endorses specifically the adoption of the Systems Interoperability Framework (SIF) as the method for exchanging data.

A fundamental tool in the NSIP programme is the Student Information System Baseline Profile (SBP), a localised version of the SIF framework and a subset of its open specifications for data sharing. Relying on the open source package created by the NSIP, the framework facilitates data exchanges between organisations. Among other applications, schools can use the SBP to automate information updates across multiple tools, or to transfer data from their local systems into a cloud-based learning management platform.

Under the umbrella of NSIP is the Learning Services Architecture (LSA), a national architectural approach based on based on established policy agreements and interoperability standards agreed jointly by education authorities and education IT companies to simplify the delivery of learning services and to ensure that education data can be used and re-used consistently at the school, education system and national levels.

Another area where interoperability standards are being applied is the digital curriculum. Australian schools can access digital repositories of learning materials through a technical infrastructure called the National Digital Learning Resources Network (NDLRN). NSIP-aligned technical and semantic standards are the tools helping make these resources more easily available, usable and discoverable by learners and educators.

More recently, NSIP has realised the Safer Technologies For Schools programme, assessing software products for cyber-security and privacy compliance, as a nationally coordinated approach building on past efforts developed within separate states. It is also coordinating a National Education Data Dictionary project, to establish national agreement around data entities in education, and to capture the range of uses, applicable legislation, and business rules that these entities are subject to.

While NSIP maintains a series of products and tools that support interoperability, it also provides advice and a contact point for schools, standard-setting organisations and companies around interoperability. It has been an important actor in the negotiation and implementation of enhanced interoperability in the Australian digital infrastructure for schools.

Source: NSIP (https://www.nsip.edu.au)

The legal layer of interoperability relates to creating conditions to enable education organisations that operate under different legal frameworks, policies and strategies to work together (European Commission, 2017[3]). Legislation can be a major roadblock for the exchange and use of education data across countries and sometimes across jurisdictions within countries, especially when there are risks for privacy and data security. The first step towards promoting legal interoperability is to perform interoperability checks by screening existing legislation to identify barriers to data flows. These may include incompatible regulations regarding data collection, storage and use across sectors or jurisdictions, different or insufficiently detailed data licensing models, obligations to use specific technical standards or technology tools, or contradictory requirements for similar business processes. As a second step, legal interoperability may require the introduction of new legislation paving the way for greater levels of data sharing and data use.

Several countries have improved their interoperability by establishing organisations or programmes supporting the negotiations of interoperable standards, taking into account the variety of policies across sub-government levels and the variety of technical standards used by different tools. Australia provides an interesting example with its National Schools Interoperability Programme (NSIP), an organisation set up to enhance interoperability across (and within) Australian states (Box 11.4). Organisational and legal interoperability are critical and probably among the most challenging layers of interoperability, as it requires people and organisations to agree on some of their organisational processes. Several initiatives launched in the past decade in different countries ended up being discontinued, which highlights the difficulty of a sustained effort in this area.

Policies and measures: where countries stand

Mandating technical interoperability

One possible measure to foster technical interoperability is to mandate the adoption of specific technical standards so that the tools in a digital ecosystem can easily "communicate" with each other. This solution can be difficult though given that technical standards evolve quickly in the digital space. Specifying standards could prevent technical innovation. When choosing to do so, countries should have quick mechanisms of consultation and communication with the education technology industry to ensure that they do not block innovation, have mechanisms to monitor technical evolutions – and have strong in-house technical expertise.

Ten countries/jurisdictions (out of 29, about one third) mandate the use of some technical standards for some of the digital tools in their education digital ecosystem (Figure 11.3 and Table 11.2). In many cases, this relates to learning management systems and other digital tools that have to be interoperable with system-wide student information systems or, in some cases, with platforms of digital learning resources. Another common case relates to privacy protection and the use of single-sign on solutions offered by public authorities: government authorities may require commercial providers to use sign-on solutions that do not give them access to any personal information about students (e.g. in France, the Netherlands of the Flemish Community of Belgium). When it comes to data, mandating the use of specific formats could relate to an expectation or request of "data portability", that is the possibility to automatically move data from one school to the next (or to allow data subjects to receive their data). Seven out of 29 countries/jurisdictions mandate data portability (and 9 more recommend it). For example, England uses a Common Transfer File, a specific technical standard to transfer student data between schools and institutions, ensuring consistency of the format of student data.

Avoiding "vendor lock-in" through open standards

Rather than mandating the use of specific standards, some countries just encourage their use. Seven countries have guidelines about the use of specific technical standards, thus providing some specific incentives. They publish technical specifications and encourage education actors to follow them. Those are mainly directed towards the education technology industry as they develop their education tools or by education stakeholders buying those products.

While the requirement or encouragement to use specific data or technical standards typically serves interoperability with system-level digital tools operated by government authorities, another interoperability challenge concerns the general interoperability of the tools in a country's digital education ecosystem. While not all digital systems need to communicate or share data with platforms of educational authorities, interoperability provides strong benefits for education actors in terms of efficiency and to be able to reuse the information gained from one tool for another. Interoperability also helps to limit the possibility of "vendor lock-in" situations, which happen when it is difficult for schools or education actors to use another digital tool (or service provider) without substantial switching costs. For example, the change of vendor may lead to the loss of all the past data they have collected. Interoperability of data formats and technical interoperability can in principle help alleviate this problem.

The use of open standards makes it easier to change systems and provides a norm that most vendors can choose to use. Encouraging the voluntary adoption of open standards is another way to promote interoperability. Interoperability and openness are two different concepts though. Interoperability refers to the ability of systems to work together, whereas openness (mainly) relates to the property rights on the solutions used to achieve it. Interoperability may thus be achieved using either proprietary or open solutions. For example, tools or products may be interoperable with each other by virtue of following the specifications set by a dominant vendor (or organisation), which makes them accessible to use under certain conditions. Openness refers to a philosophy started by the open software movement that makes the source code of specific software available to all for reuse and for improvement. In the case of education, open standards usually provide a common, non-proprietary language for integrating multiple forms of digital content and data into vendor-neutral platforms (CoSN, 2017[8]). When standards are open, any other organisation can reuse them with ease or sometimes create tools to create some level of interoperability between their digital tools and this open standard.

Among the 29 countries that have answered the OECD survey on digital infrastructures and governance, 7 have rules requesting the use of open data standards, and 10 for open technical standards – for at least some specific use cases (and not necessarily all solutions). (The above-mentioned specific standards authorities require to use may be open or not.) When considering guidelines in addition to formal rules, 11 countries recommend following open standards for education data and 7 for technical standards.

Estonia is probably one of the countries where levels of interoperability of the digital education ecosystem are among the highest, thanks to interoperability of all government tools and the use of the X-tee tool. To streamline data portability across systems while safeguarding the protection of data and the privacy of education stakeholders, the *X-tee* open-source solution is a centrally managed data exchange layer, originally developed by the Information System Authority (*Riigi Infosüsteemi Amet*). *X-tee* facilitates secure and standardised data exchange among diverse IT systems, encompassing government databases and private sector systems.

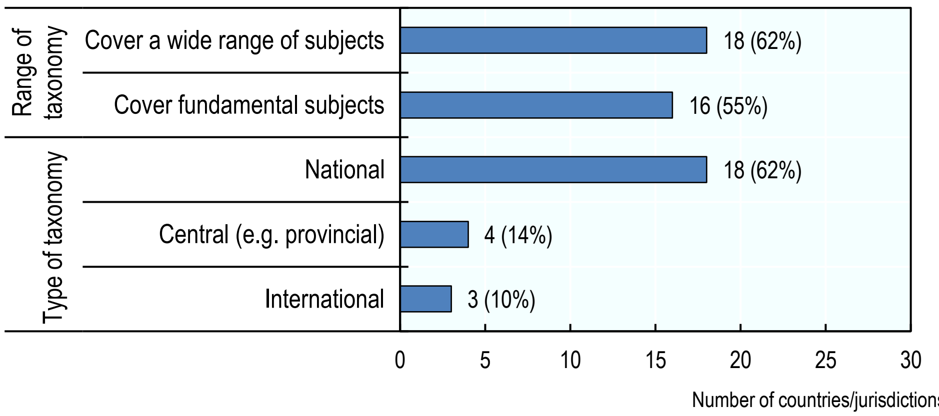
Beyond the publication or endorsement of specific (sometimes open) standards, countries could incentivise vendors to use them through procurement processes. Three out of 29 countries that participated in the OECD survey on digital infrastructure and governance include some interoperability criterion in their procurement processes (Vidal, 2023[14]).

Encouraging the use of controlled taxonomies for digital learning resources

The use of standards for indexing digital learning resources is another example of using and encouraging the use of specific (usually open) standards. Eighteen countries/jurisdictions out of 29, that is about two thirds, have national taxonomies for their learning resources. A few countries (3 out of 29, about 10%)

follow international taxonomies. National taxonomies may be derived from international taxonomies though. These taxonomies usually cover a wide range of subjects (18 countries) in addition to mathematics and domestic language(s), which are usually the two subjects included in countries' national evaluations.

Figure 11.2. Country use of taxonomy for digital learning resources (2024)



Note: N=29.

StatLink https://stat.link/4fyjop

Table 11.1. Taxonomy for digital learning resources (2024)

	Type of taxonomy			Range of taxonomy	
	International	National	Central (e.g., provincial)	Cover fundamental subjects	Cover a wide range of subjects
Austria		✓		✓	✓
Brazil		✓		✓	
Canada					
Chile	✓	✓		✓	✓
Czechia					
Denmark					✓
Estonia		✓		✓	✓
Finland					
France		✓		✓	✓
Hungary		✓		✓	✓
Iceland					
Ireland		✓		✓	✓
Italy		✓		✓	
Japan		✓		✓	
Korea		✓			✓
Latvia		✓		✓	✓
Lithuania		✓		✓	✓
Luxembourg					✓
Mexico		✓		✓	✓
Netherlands					
New Zealand		✓		✓	✓
Slovenia		✓			✓

	Type of taxonomy			Range of taxonomy	
	International	National	Central (e.g., provincial)	Cover fundamental subjects	Cover a wide range of subjects
Spain		✓		✓	✓
Sweden					
Türkiye					✓
United States		✓	✓	✓	✓
England (United Kingdom)		✓	✓		✓
Flemish Comm. (Belgium)	✓		✓		
French Comm. (Belgium)	✓		✓	✓	✓
Total (29)	**3**	**18**	**4**	**16**	**18**

Note: Finland have a national metamodel for digital learning materials that is linked to ePerusteet, that makes it possible to link digital materials to curriculum subjects/contents. While this is not a taxonomy per se, it provides an interoperability model based in LRMI and contains small parts of LOM-model. While not ticked in the table, Finland is close to having a national taxonomy that covers fundamental subjects. N=29.

StatLink https://stat.link/otimkw

Most of the national taxonomies related to educational content are based on countries' national curriculum. Digital learning resources developed by both commercial and governmental actors are often mapped against them. For example, in Japan, digital educational materials are tagged according to a national taxonomy assigning each subject of the curriculum a number, so that teachers can easily find the related curriculum content they need. New Zealand also uses its national curriculum to provide a framework for taxonomy and to accordingly classify digital resources. Ireland's national standard taxonomy is also based on its curriculum.

Some countries adopt international taxonomies to standardise digital educational resources, thus providing commercial vendors with a way to tag their learning resources. For instance, Chile uses the Dublin Core mentioned above, with extensions to the Chilean curriculum. EducarChile, the nation's digital learning resource portal for teachers and students, tags its resources according to this framework.

France and the French community of Belgium generally use another localised international standard for tagging teaching and learning resources: the Learning Object Metadata (LOM) (see Box 11.3). France developed the *ScoLOMFR* adaptation for its school sector, which is also used by the French-speaking Community of Belgium for its e-classe platform. In addition, the MOTBIS thesaurus helps tagging of resources and keyword indexing in a consistent manner for learning materials in the e-classe platform. The MOTBIS thesaurus is based on controlled vocabulary lists of the National Library of France. One of its limitations of the LOM standard is that subjects and contents within subjects are not standardised (even though they are required descriptions). This is one of the reasons why domestic adaptations are needed.

In some cases, actors may follow a common taxonomy with no request to do so. In Finland, although the government does not publicly provide or endorse a controlled taxonomy for learning objects, resource providers voluntarily tag their resources according to the national curriculum.

Certification

Another possible approach would be for countries to request digital tools to undergo a certification process comprised of interoperability dimensions. For example, they may develop a standard with the International

Standardization Organisation (ISO) or their domestic standardisation organisation and request that digital tools in their digital ecosystem follow a certified standard that includes an interoperability dimension. Requesting certification for public procurement is common in other sectors than education. For example, in their efforts to improve the quality of school canteens, some countries or municipalities may require that some ingredients (or a percentage of ingredients) are certified “organic”, as is the case in Rome (Italy) as well as in other municipalities in other countries. Asking for “certified” solutions as part of procurement processes is not uncommon. As mentioned above, the Access 4 Learning Community does certify digital products that follow their standards. Some of the standards for tagging digital learning resources could lead to certification, although this does not appear to be the case as of 2023. Depending on the cases, this may be a burdensome approach though, and countries should consider the costs (and thus possible disincentives) for third parties as well as the benefits for the education system. Table 11.1 shows that Austria, Denmark, and Mexico use this policy, while four other countries recommend it. None of the countries provided examples of the required certifications.

Single sign-on (SSO)

A recent strategy that has been adopted by many countries is the development of “single sign-on” solutions. A single sign-on is an “identity management” solution, as mentioned above. It allows end users to access (and be authenticated) by using a single ID to any of several related, yet independent, software systems. The systems do not need to be interoperable (apart from that authentication element), but they provide an ease of access that achieve what interoperability looks like for an end user: the feeling of integration of various digital tools.

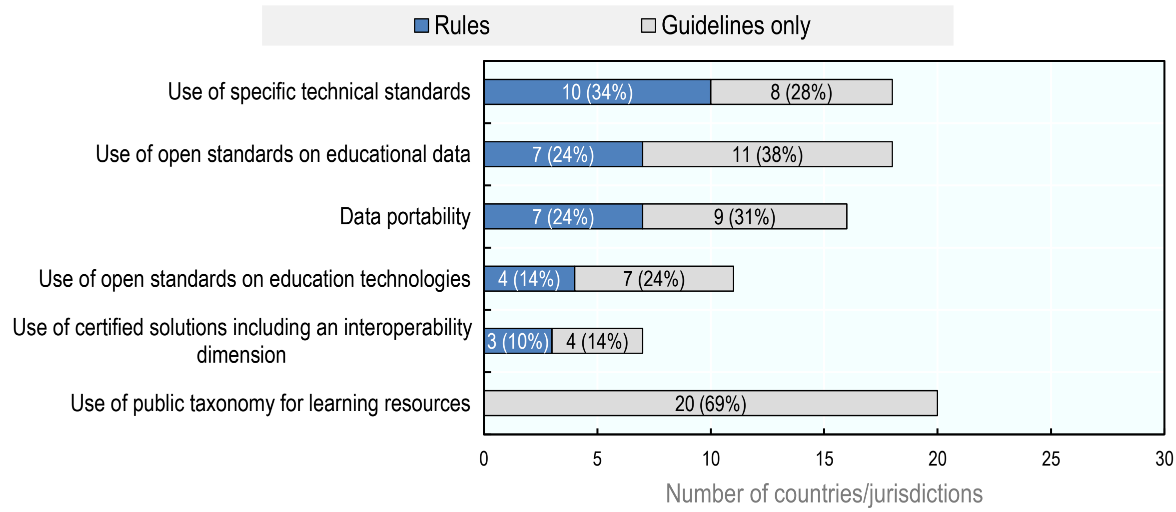
For instance, England supports DfE Sign-in, a single sign-on (SSO) service, for their two student information systems (Analyse School Performance and Get Information About Pupils) and online register for schools (Get Information About Schools). Korea also promotes the use of the single sign-on (SSO) system for Edunet T-Clear applications to improve data portability by setting relevant guidelines. Denmark implemented the UNI login, and Finland developed its own MPASSid sign-on service.

In some cases, for example in France, the single sign-on tools are also used as a feature of their data protection and privacy policies to also ensure that vendors do not have information about the identity of the registered teachers or students using the different systems.

Summary

Figure 11.3 and Table 11.2 provide a summary of the reviewed aspects of interoperability policies implemented by countries.

Figure 11.3. Interoperability rules and guidelines (2024)



Note: N=29.

StatLink https://stat.link/70mlvh

Table 11.2. Interoperability measures by countries (2024)

	Use of specific technical standards		Use of open standards on education technologies		Use of open standards on educational data		Use of certified solutions including interoperability dimensions		Data Portability		Procurement	Engagement
	Rules	Guidelines	Rules	Guidelines	Rules	Guidelines	Rules	Guidelines	Rules	Guidelines	Criteria on interoperability	International initiatives
Austria	✓			✓		✓	✓			✓		
Brazil		✓				✓						
Canada						✓						
Chile				✓	✓							
Czechia		✓										✓
Denmark	✓				✓		✓			✓		
Estonia		✓	✓		✓							
Finland	✓				✓							
France	✓					✓						✓
Hungary	✓								✓		✓	✓
Iceland									✓			
Ireland										✓		
Italy		✓	✓			✓			✓			
Japan		✓				✓				✓		
Korea				✓		✓		✓		✓		✓
Latvia			✓		✓				✓			
Lithuania	✓									✓	✓	✓
Luxembourg									✓			

	Use of specific technical standards		Use of open standards on education technologies		Use of open standards on educational data		Use of certified solutions including interoperability dimensions		Data Portability		Procurement	Engagement
	Rules	Guidelines	Rules	Guidelines	Rules	Guidelines	Rules	Guidelines	Rules	Guidelines	Criteria on interoperability	International initiatives
Mexico	✓						✓					
Netherlands		✓		✓		✓		✓		✓		
New Zealand		✓				✓						
Slovenia				✓					✓			✓
Spain												
Sweden						✓				✓		
Türkiye												✓
United States		✓		✓		✓		✓				
England (United Kingdom)	✓								✓		✓	
Flemish Comm. (Belgium)	✓			✓	✓							
French Comm. (Belgium.)	✓		✓		✓			✓		✓		
Total (29)	10	8	4	7	7	11	3	4	7	9	3	7
Total (29)	**18**		**11**		**18**		**7**		**16**		**3**	**7**

Note: N=29.

StatLink https://stat.link/78ez32

Conclusion and policy pointers

Interoperability matters to make a digital education ecosystem more efficient, effective and integrated. Promoting interoperability is a policy response to the problem of a fragmented digital ecosystem. In many countries, educational organisations collect a lot of data but suffer from poor usability of those data to make them inform decisions. These include limited consistency and interpretability of education data that do not conform to semantic standards, untimeliness, and poor accessibility of data when digital education systems are unable to communicate with each other. For example, next-generation information systems, a cornerstone of new models of education data use for innovation and improvement purposes, can only deliver their full potential in an environment shaped by the principles of interoperability. Even in the age of artificial intelligence, searching efficiently for digital learning resources is easier when learning resources are catalogued according to standard taxonomies. This also makes resources more easily interoperable or accessible by schools' learning management systems.

The transition from a fragmented to an interoperable educational technology and data ecosystem builds on some important policy dimensions. These include dealing with legacy systems, increasing awareness of the benefits of interoperability, putting in place an effective mix of incentives and mandates for the adoption of standards, ensuring sustainability and capacity to adapt to changing needs, and taking advantage of international initiatives in this area.

Dealing with legacy digital systems and data models

The limited capacity of existing infrastructure to exchange data with other systems as well as the lack of common models defining key educational processes and outcomes can impose substantial constraints for innovative uses of education data. Interoperability in such systems should not be seen as an unsurmountable challenge. Rather than a radical infrastructure replacement or a full definitional overhaul, the transition towards a more interoperable digital education ecosystem can proceed in small stages and build on existing data collections and digital systems.

Regarding semantic interoperability, two approaches could be considered:

- Where a set of quality data standards that could improve interoperability is not yet available, efforts could focus on the strategic and collaborative design of standards that build on existing data models, data dictionaries and data format specifications. The development of those standards should be related to well-identified use cases with high value for policy design or teaching and learning interventions. A potential strategy is to bring stakeholders together in order to identify a set of data elements in overlapping areas of interest and use these elements as the skeleton for the design of a broader data model. If consensus can be reached on a set of core data elements that different agencies and actors need to address their most pressing policy and practical questions, interoperability initiatives can then focus on developing standards for such core elements. This is the approach that was taken in the case of developing taxonomies for digital learning resources.
- Where set of quality data standards have already been established, education agencies could carry out an exhaustive mapping and gaps analysis of their current technical infrastructure on the semantic layer of interoperability. The aim of this exercise is to identify data elements and practices that are not aligned with the desired interoperability architecture, as well as areas where such alignment exists already, and no major changes are needed. For instance, the mapping tool Align developed by the CEDS initiative in the United States (see Box 11.2) allows state and local education agencies to see which of the data elements they currently collect are in a format aligned to the CEDS and which elements would require changes in their collection and formatting procedures. The tool automates the mapping analysis when agencies upload their own data dictionaries and compare them to the CEDS.

Technical interoperability is often less malleable as technical standards are typically defined by system developers in the education technology industry. The second approach of mapping and gaps analysis could still be used for technical interoperability, again related to clearly identified use cases. Technical interoperability projects designed with a gradual approach will require neither full nor immediate compliance with standards. Full compliance may not be a realistic option for digital education ecosystems that use a diversity of proprietary IT solutions. A gradual approach may thus involve the creation of bridging mechanisms that facilitate the transfer of data from and communication between non-interoperable systems during a transition phase.

Providing incentives for interoperability

Governments can promote interoperability in different ways.

One radical way is to provide and procure centrally all digital tools and resources in their education system, assuming that they pay attention to their interoperability. The risk of such an approach is that the digital education ecosystem quickly becomes obsolete as the government incentives to make it evolve are usually limited. One of the challenges that interoperability addresses is in fact to allow for diversity and innovation while keeping the digital ecosystem efficient and effective.

Regulation by public education agencies is a major driving force for the adoption of interoperability-aligned standards and practices. Regulatory action touch on multiple areas, including data submission and reporting requirements (e.g. requiring schools to submit data and reports using specific standards), certification requirements to technology vendors (i.e. mandating that systems entering the market are compatible with established standards) and rules for public procurement processes (i.e. prescribing interoperability as a condition for purchase). Regulation can vary in strength, from formal mandates with well-defined conditions and timeframes for implementation, to guidelines or even incentive mechanisms in competitive grants and other public funding requests. All of these strategies are already used to some extent.

Market incentives can also play an important role in the adoption of standards, both in the technical and semantic layers. Market competition can incentivise technology developers to design data management tools and digital learning resources that use vendor-neutral and standards-aligned definitions, formats, and transport layers. The increasing digitalisation of schools increases the value to vendors of tools and resources that can interact with other applications. As this expectation is increasingly reflected in procurement processes for educational technology and learning resources, the demand for interoperable tools and resources becomes stronger. Procurement for educational technology solutions could therefore give a stronger consideration to data and technical standards that enable interoperability. A potential strategy for public education agencies is to require that purchased applications can meet interoperability goals, or, at a minimum, that vendors have a plan to support this transition. Education organisations could thus evaluate any potential technology investment based on the ability of new solutions to interact with existing data and applications (Fox et al., 2013[2]; Bailey et al., 2014[15]).

Open standards are also potentially an enabler of adaptability, which can boost innovation through the supply of new technology solutions and services better adapted to local needs without the need to create and maintain numerous complete systems. A market that relies on interoperable and modular technologies is more attractive to new players than a market based on locked-in solutions that cannot work with each other. This is the idea of “digital platforms” such as current smartphones and their related app stores. In this sense, interoperability can support incremental innovations in digital systems and services, for instance in learning analytic tools that mine and combine data maintained in a variety of local systems (Cooper, 2014[16]).

Promoting awareness of the benefits of interoperability

The successful implementation of interoperability-enabling standards will to a large extent rest on achieving a shared perception of the benefits that interoperability can bring about. Agencies and organisations will be more likely to modify their data collections, digital systems and management practices to make them conform to standards when they see how the use of common definitions and formats and interoperable standards can put them in a better position to achieve their goals.

This involves gaining clarity about how standards can help them meet informational needs, for instance by enabling more meaningful comparisons with other entities, and how this can be turned into actions. Cost savings that may arise in the medium and long term should also become visible, as when the use of standards results in more efficient data collection and exchange processes (e.g. once-only collection, less redundancy, less validation checks), even if their adoption involves some initial costs. Here again, clear use cases should be established, showing how the data collected by a specific digital tool could improve the recommendations or efficacy of another one.

Policies promoting an understanding of interoperability principles and raising awareness about its potential benefits for educational organisations can thus contribute to creating demand for interoperability across the sector. Actions in this area include information and advocacy campaigns that disseminate a clear definition of interoperability and describe its different layers, present a feasible roadmap for the adoption of standards, and address legitimate concerns about its implications for data use, especially regarding privacy and security. This requires “organisational” interoperability and programmes or agencies that not only advocate for interoperability but work with stakeholders on specific projects that highlight its tangible value for the system. This can thus take the form of establishing organisations or projects focused on stakeholder collaboration towards better interoperability.

Evolving standards for sustainable interoperability policies

Interoperability cannot be achieved for ever as data needs, technological possibilities and technical standards evolve over time. Interoperability policies can only be effective when designed for sustainability, with continuous effort and iteration.

Regarding the semantic layer, regular consultation with actors involved in education data collection or digital learning resources use and production can bring important benefits. Semantic standards may be developed through a collaborative process as a way of increasing stakeholder buy-in for the long run, and of benefiting from the practical experience accumulated by these stakeholders in different contexts. An inclusive and collaborative process for defining common data standards derives from the recognition that stakeholders want to use data for different purposes. Different types of information will be relevant in different contexts. Standards can thus be recurrently reviewed as new needs emerge, as organisations seek to facilitate more data sharing, and as problems with existing standards are identified.

Regarding the technical layer, the rapid pace of technological change calls for mechanisms that enable periodic and easy-to-implement updates of data and technical standards and data exchange protocols. Not surprisingly, along with changing technology comes the need for new solutions for enabling the interaction between emerging applications. It is in this respect that open technical solutions and extendable platforms present clear advantages over proprietary solutions, even if the latter enable interoperability at a given point in time. Education agencies may therefore benefit from prioritising open licence interoperability solutions which carry a lower risk of vendor lock-in and may prove more cost-effective over time.

One challenge and tension in interoperability policies is to balance mandates for interoperability of solutions at a given point in time against innovation and efficacy. The quest for interoperability should not prevent digital ecosystems to evolve and innovation to take place – quite the contrary. Depending on their technical competences and resources in continuously monitoring the evolution of technical standards, education agencies and governments should be more or less prescriptive in their interoperability policies.

Engaging in international initiatives

Finally, countries should more systematically engage in an international dialogue about interoperability, for both the semantic and technical layers. International organisations could represent the organisational layer to coordinate that dialogue.

Only 7 out 29 countries/jurisdictions were actively engaged in international dialogues for interoperability in 2024. For instance, Australia, Canada, New Zealand, the United States, and the United Kingdom are involved in the Access 4 Learning community (see Box 11.1. Integrated suites of technical standards). Sweden’s National Agency for Education is a member of the Swedish Institute of Standards and its technical committee for Education (TK450), which actively participates in standardisation and interoperability projects at the international level. The Nordic and Baltic countries collaborate on project on cross-border data exchange, with a use case about the transfer of digital study records across those countries (Dahl et al., 2021[17]).

Engaging in a dialogue about semantic and technical interoperability across countries could lead to many possible benefits: automating international education statistics; increasing the size of the digital education market and making it more attractive for developers and vendors; mutualising digital learning resources by making them easier to search and find, including in other languages. Even though differences in languages, cultures and systems will require always limit the possibilities for interoperability, efforts towards semantic and technical interoperability offers many possibilities at the international level as well. The use cases just need to be identified.

References

Abdel-Qader, M., A. Saleh and K. Tochtermann (2021), “On the experience of federating open educational repositories using the learning object metadata standard”, *EDULEARN21 Proceedings*, pp. 4819-4825, https://doi.org/10.21125/edulearn.2021.0998. [13]

Bailey, J.; D. Owens; C. Schneider; T. van der Ark and R. Waldron (2014), *Guide to EdTech Procurement*, Digital Learning Now, http://digitallearningnow.com/site/uploads/2014/05/Procurement-Paper-Final-Version.pdf (accessed on 19 December 2018). [15]

Cooper, A. (2014), *Learning Analytics Interoperability. The Big Picture in Brief*, Learning Analytics Community Exchange (LACE), http://www.laceproject.eu/publications/briefing-01.pdf (accessed on 19 December 2018). [16]

CoSN (2017), *Working Together to Strategically Connect the K–12 Enterprise: Interoperability Standards for Education*, Consirtium for School Networking (CoSN), https://www.cosn.org/wp-content/uploads/2021/09/CoSN-Interoperability-Standards-for-Education-for-Non-Technical-Leaders.pdf. [8]

Dahl, A; M. Reetta; L. Olkkonen; H. Saarinen; T. Sandell and T. Törnroos (2021), *Baseline study of cross-border data exchange in the Nordic and Baltic countries*, Nordic Council of Ministers, https://doi.org/10.6027/temanord2021-547. [17]

European Commission (2017), *New European Interoperability Framework*, Publications Office of the European Union, Luxembourg, https://doi.org/10.2799/78681. [3]

Fox, C.; D. Schaffhauser; G. Fletcher and D. Levin (2013), *Transforming Data to Information in Service of Learning*, http://setda.org/web/guest/datatoinformation. [2]

Gasser, U. and J. Palfrey (2007), *When and How ICT Interoperability Drives Innovation*, The Berkman Center for Internet & Society at Harvard Law School, https://cyber.harvard.edu/interop/pdfs/interop-breaking-barriers.pdf. [1]

Guijarro, L. (2007), “Interoperability frameworks and enterprise architectures in e-government initiatives in Europe and the United States”, *Government Information Quarterly*, Vol. 24/1, pp. 89-101, https://doi.org/10.1016/J.GIQ.2006.05.003. [6]

Hauser, R. and J. Anderson Koenig (eds.) (2011), *High School Dropout, Graduation, and Completion Rates*, National Academies Press, Washington, D.C., https://doi.org/10.17226/13035. [10]

Kubicek, H., R. Cimander and J. Scholl (2011), *Organizational interoperability in e-government : lessons from 77 European good-practice cases*, Springer. [4]

National Forum on Education Statistics (2010), *Traveling Through Time: The Forum Guide to Longitudinal Data Systems. Book Two of Four: Planning and Developing a LDS*, Washington, DC: National Center for Education Statistics. [11]

Redd, B. (2013), *Of That: A Taxonomy of Education Standards*, https://www.ofthat.com/2013/03/a-taxonomy-of-education-standards.html (accessed on 28 June 2018). [7]

Redd, B. (2012), *A Four-Layer Framework for Data Standards*, http://x.ofthat.com/papers/fourlayer.pdf. [5]

Vidal, Q. (2023), “Public procurement: shaping digital education ecosystems”, in *OECD Digital Education Outlook 2023. Towards an Effective Digital Education Ecosystem*, OECD Publishing, https://doi.org/10.1787/c74f03de-en. [14]

Vincent-Lancrin, S., C. Cobo Romaní and F. Reimers (eds.) (2022), *How Learning Continued during the COVID-19 Pandemic: Global Lessons from Initiatives to Support Learners and Teachers*, OECD Publishing, Paris, https://doi.org/10.1787/bbeca162-en. [12]

Vincent-Lancrin, S. and C. González-Sancho (2023), “Education and student information systems”, in *OECD Digital Education Outlook 2023. Towards an Effective Digital Education Ecosystem*, OECD Publishing, https://doi.org/10.1787/c74f03de-en. [9]

12 Public procurement: shaping digital education ecosystems

Quentin Vidal, OECD

This chapter provides an overview of countries and jurisdictions' procurement policies and practices on digital education. It examines how countries and jurisdictions leverage multiple procurement strategies, from centralising procurement through to providing guidance and support on how – and sometimes what – schools should procure in terms of digital tools and resources. The chapter casts light on procurement as a way to shape countries' digital ecosystems, showcasing existing (often non-binding) procurement guidelines set to ensure data protection and security, improve interoperability, and, to a lesser extent, foster equity and effectiveness.

Introduction

Digitalisation has made technology-related products and services integral parts of countries' educational infrastructure, whether they support system and school management or with teaching and learning (see Part I of this Volume). This infrastructure encompasses both hardware (e.g., digital materials, Internet connectivity) and software (e.g., information and learning management systems, digital teaching and learning resources), as well as teacher digital training and development, and data security and privacy services. With different approaches, countries procure digital tools and resources from commercial vendors in the educational technology industry (hereafter "EdTech"). Publicly procured tools may be used by governments themselves, by schools, teachers, and students. Even for tools and resources that are neither publicly provided nor procured, governments may guide and regulate schools', teachers' and students' procurement processes in education. This is particularly important as technology tools and resources are typically more expensive than textbooks and other educational materials and might require an expertise that is not typically available in educational settings.

Public procurement, also known as government procurement, refers to the formal procedures and processes by which government entities, such as central, federal, state, or local governments, agencies, or state-owned enterprises, purchase goods, services, or works from external suppliers or vendors (OECD, 2009[1]). It includes the acquisition through purchase, rental, or lease, but also public-private partnerships, concessions, and other contractual arrangements, as well as the use of public funds for grants, loans, and other forms of financial assistance.

In the context of education, public authorities resort to procurement to acquire various products and services that they consider necessary for the functioning of the education system and schools but that they do not develop, own, and provide themselves. Public procurement in education ranges from the purchase of textbooks, school supplies, building maintenance services, transportation services, up to the construction of new educational facilities. This chapter focuses on the procurement of soft digital infrastructure (software tools and resources) and does not cover hardware procurement (see (Fragoso, 2023[2])).

Public procurement typically involves several stages. After a government identifies the needs, it publishes a request for proposals (RFP) or a tender document, inviting bids from potential suppliers in a transparent and competitive manner. Typically, a selection committee assesses these bids based on pre-defined criteria, leading to the awarding of the contract to the chosen supplier, often following negotiations on terms and conditions. Once the contract is in effect, monitoring mechanisms may be employed to uphold quality and compliance with the agreed-upon terms.

These processes are designed to ensure transparency, fairness, competition, and accountability in government spending (OECD, 2021[3]). The OECD Recommendation on the Governance of infrastructure highlights 1) selecting contractors based on criteria combining qualitative and financial elements and including an assessment of costs, benefits and impacts incurred throughout the life cycle of the asset; 2) carefully evaluating optimal risk allocation and the use of value-for-money analytical tools to compare assessments of service delivery options; and 3) implementing balanced contractual relationships, holding contractors accountable for project specifications and professional standards.

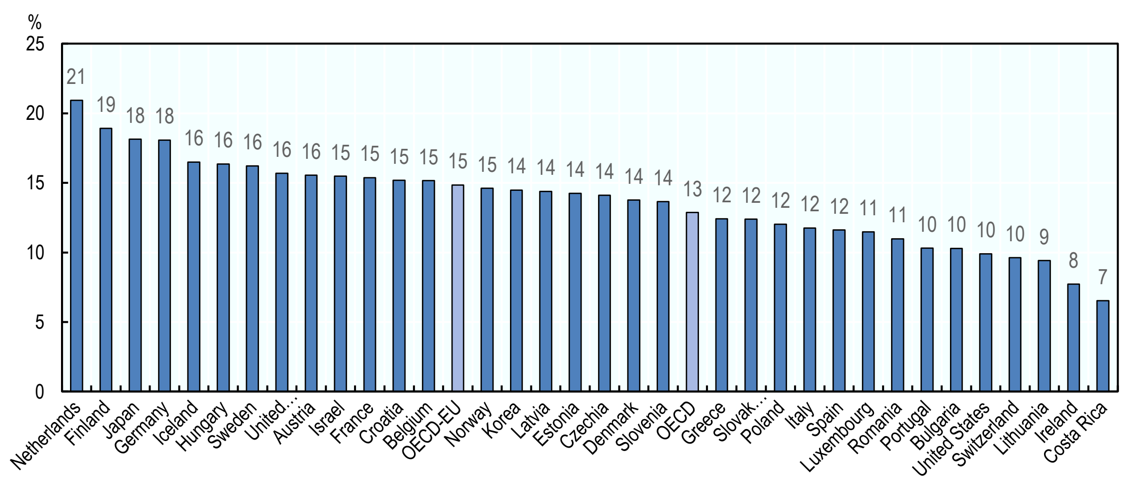
In education specifically, countries have set guidelines and guardrails to ensure that taxpayer funds are used to procure equitable and effective tools and resources. In particular, for countries with more decentralised governance and devolved lines of responsibility, ensuring the equity of access to, and use of, digital infrastructure in schools is a challenge. Centralising public procurement, or centralising the regulation of schools' and teachers' procurement, may help provide at least a homogenous access to the main components of a digital education infrastructure – even if gaps may remain in practice.

This chapter is organised as follows: it starts by presenting some of the procurement policies and practices across countries, notably with information collected through the OECD survey on digital education infrastructure and governance. It highlights the different strategies used by countries and the different objectives pursued by countries. The conclusion summarises the findings, points to some tensions in procurement regulation efforts and highlights the importance of public procurement to reach its policy objectives by incentives.

A state of the art

Governments procure large amounts of goods and services to implement policies and deliver public services across sectors. Public procurement expenditure as a share of gross domestic product (GDP) increased significantly across the OECD over the last decade, from 11.8% of GDP in 2007 to 12.9% of GDP in 2021 (OECD, 2023[4]). Public procurement is used across all socio-economic objectives, from health to environmental protection, public order and economic affairs (comprising infrastructure, transport, communication, energy and R&D). While health accounts for the largest share of public procurement spending, at 31.9% of an average OECD country's public procurement in 2021, education comes third, at 10.7%, with relatively small variations across countries (Figure 12.1, Figure 12.2Figure 12.3). However, comparative evidence on public expenditure digital education remains limited (Box 12.1).

Figure 12.1. Public procurement expenditure as percentage of GDP (2021)



Note: Countries are ranked by the proportion of their public procurement spending that they allocate to education. Data are not available for Australia, Canada, Chile, Colombia, Mexico, New Zealand and Türkiye. Data for Costa Rica are not included in the OECD average. Data for Costa Rica and Korea are for 2020 rather than 2021.Sources: OECD National Accounts Statistics (database); Eurostat Government finance statistics (database).
Source: Government at a Glance (OECD, 2023[4]).

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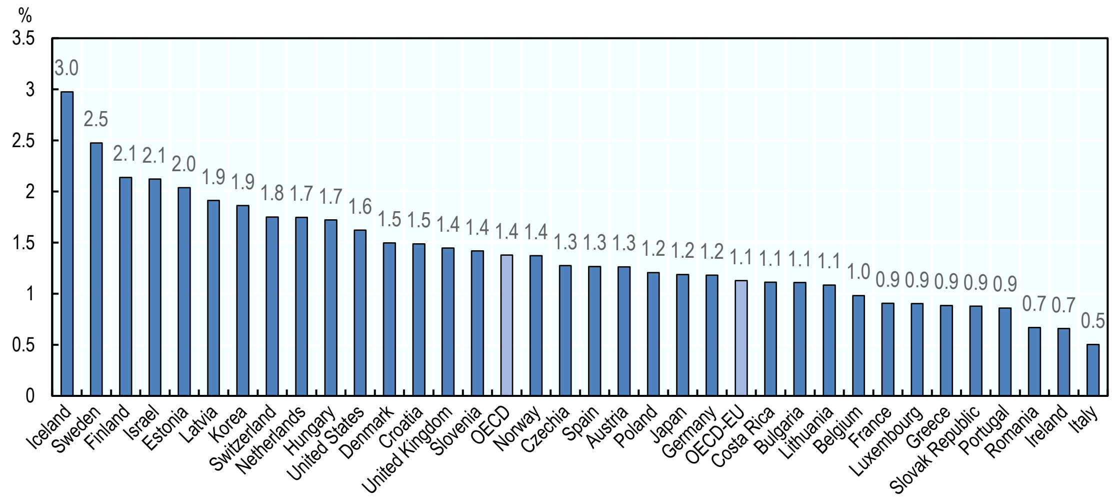
Figure 12.2. Public procurement expenditure in education as percentage of GDP (2021)



Note: Countries are ranked by the proportion of their public procurement spending that they allocate to education. Data are not available for Australia, Canada, Chile, Colombia, Mexico, New Zealand and Türkiye. Data for Costa Rica are not included in the OECD average. Data for Costa Rica and Korea are for 2020 rather than 2021.Sources: OECD National Accounts Statistics (database); Eurostat Government finance statistics (database).
Source: Government at a Glance (OECD, 2023[4]).

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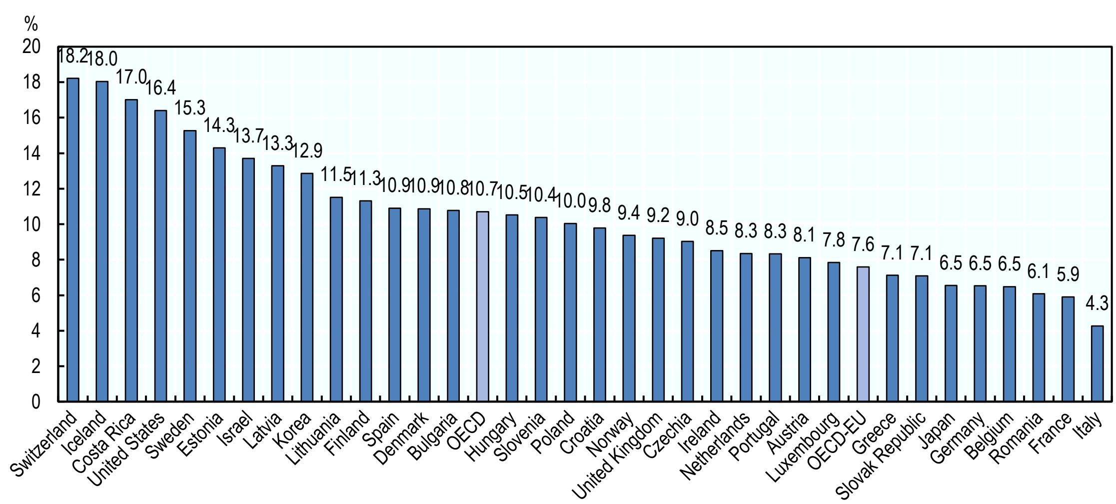
Figure 12.3. Public procurement in education as a share of all public procurement expenditure (2021)



Note: Countries are ranked by the proportion of their public procurement spending that they allocate to education. Data are not available for Australia, Canada, Chile, Colombia, Mexico, New Zealand and Türkiye. Data for Costa Rica are not included in the OECD average. Data for Costa Rica and Korea are for 2020 rather than 2021.Sources: OECD National Accounts Statistics (database); Eurostat Government finance statistics (database)
Source: Government at a Glance (OECD, 2023[4]).

StatLink https://stat.link/7lirat

Box 12.1. Resourcing digital infrastructure in education: limited availability of comparative evidence on funding and cost-efficiency

Investments are smaller in education than in other sectors…

While data on public spending on digital education are hard to obtain, estimates from the private sector can give some idea of digital education spending. Market estimates indicate that global expenditure by governments, employers and consumers on hardware, software and technology-enabled services has intensified, but it represents a small share (4%) of global spending on education and training – way below what is spent on health and climate action for instance. (HolonIQ, 2020[5]; HolonIQ, 2021[6]).

… and not all investments are cost-efficient.

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[7]). 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). Substantial research evidence showed 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[8]; Escueta et al., 2017[7]). Should this still be the case, the enhancement of digital skills and the modernisation of education remains an important educational policy objective 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.

Source: (OECD, 2023[9]). *Shaping Digital Education: Enabling Factors for Quality, Equity and Efficiency*, OECD Publishing, Paris, https://doi.org/10.1787/bac4dc9f-en.

Our comparative analysis covers 29 countries and jurisdictions The answers to the questionnaires were validated through meetings with the responding country team and expanded through desk research (see the related publication *Country Digital Education Ecosystems and Governance. A companion to Digital Education Outlook 2023* (OECD, 2023[10]).

Most of the countries and jurisdictions that have taken part in our data collection centrally procure some digital tools and resources for schools (European Commission, 2023[11]). Out of 29 countries/jurisdictions, 21 (or more than two thirds) centrally procure some of those digital tools and resources, and 11 (more than a third) mandate another organisation to do it, generally a public agency (Table 12.1 and Figure 12.1, Figure 12.2 and Figure 12.3).

In the eight countries and jurisdictions that do not centrally procure digital tools and resources, the central government plays little to no role in the provision and maintenance of the digital education infrastructure (e.g., Czechia and the Netherlands, where schools are free to procure their own digital solutions as long as they meet government-set targets); central governments devolve most responsibilities to lower levels of government (e.g. to states in the United States or to municipalities in Finland and Sweden) or central governments develop and own (instead of procure) most of the digital solutions they provide, leaving schools the autonomy to add to that ecosystem through their own procurement (e.g. Italy, the French community of Belgium). All of them, except Czechia and Finland, provide procurement guidance to their schools.

Table 12.1. Countries' procurement practices from the central/jurisdictional level of government (2024)

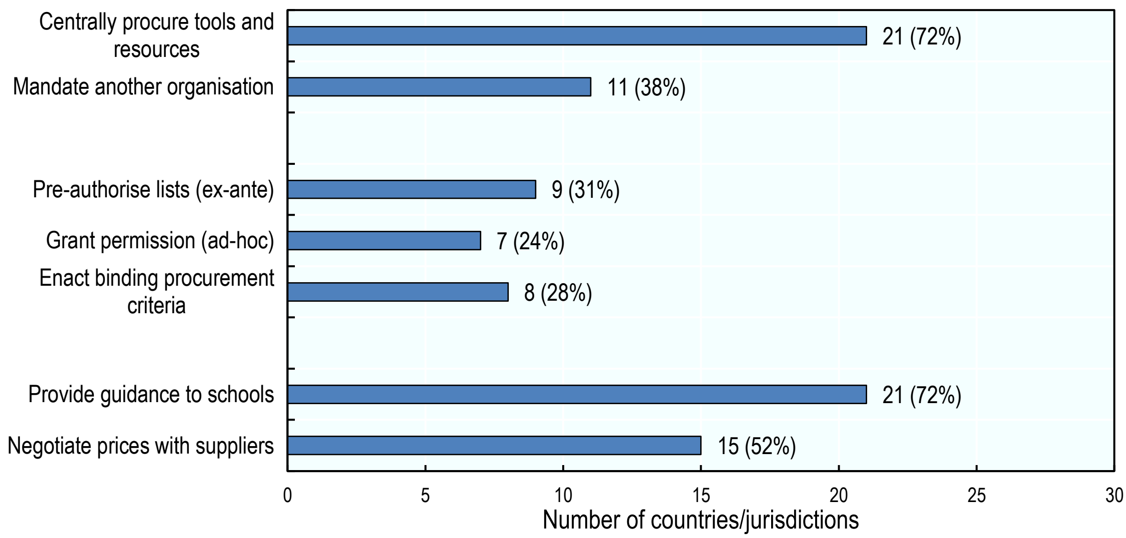
	Central procurement		Central regulation for devolved procurement			Central support for devolved procurement	
	Directly procure tools and resources	**Mandate another organisation** to procure tools and resources	**Pre-authorise** a list of tools and resources than can be purchased (***ex-ante***)	**Grant permission** upon the purchase of specific tools and resources (***ad-hoc***)	**Enact binding criteria** on procurement to foster…	**Negotiate prices** with suppliers of tools and resources	**Provide guidance** to schools
Austria	✓	✓	✓			✓	✓
Brazil	✓		✓		Security	✓	✓
Canada	✓*				Equity of access*, Security*,	✓*	✓*
Chile	✓			✓			
Czechia							
Denmark	✓	✓	✓	✓*	Security		✓
Estonia	✓	✓		✓*		✓	✓
Finland							
France	✓	✓			Equity of access, Security, Interoperability		✓
Hungary	✓	✓				✓	
Iceland	✓	✓				✓	
Ireland	✓	✓	✓			✓	✓
Italy			✓	✓	Security, Sustainability		✓
Japan	✓		✓				✓
Korea	✓	✓		✓*		✓	✓*
Latvia	✓	✓		✓	Security, Sustainability	✓	✓
Lithuania	✓	✓				✓	✓
Luxembourg	✓		✓			✓	✓
Mexico	✓		✓				
Netherlands							✓
New Zealand	✓	✓				✓	
Slovenia	✓					✓	✓
Spain	✓			✓			✓*
Sweden							✓
Türkiye	✓					✓	
United States					Equity of access*, Security*		✓
England (United Kingdom)							✓
Flemish Comm. (Belgium)	✓				Security	✓	✓
French Comm. (Belgium)			✓				✓
Total	**21**	**11**	**9**	**7**	**8**	**15**	**21**

Note: A star (*) indicates that this specific mechanism is conducted at the subnational level of government, for instance provinces and territories in Canada, or municipalities in Denmark.

StatLink https://stat.link/7gs1ul

Figure 12.4. A snapshot of countries' procurement practices from the central/jurisdictional level of government (2024)

Practices are grouped according to the procurement type they apply to, from central provision to school procurement.



Note: N=29

StatLink https://stat.link/bgihwj

Countries leverage multiple procurement strategies

Countries have different governance approaches to public procurement in education, and in digital education in particular. Those approaches generally follow the lines of governance and responsibility of the education systems. The sections below categorise those mechanisms from the more centralised to the more decentralised approaches, noting that such mechanisms are not mutually exclusive. Our study indicates that countries typically resort to a mix of different approaches.

Leveraging central procurement

Out of 29 countries/jurisdictions for which we have comparative information, 21 (that is, more than two thirds) centrally procure digital tools for system and school management digital or resources for teaching and learning, or both. Among them, 11 share this responsibility with a national agency that sits outside of the ministry (or department) of education.

Typical cases of direct procurement conducted from the central level concern the large-scale acquisition of licences to allow for massive access to and use of products or services from commercial EdTech providers. For instance, in Austria (see Box 12.2), the Flemish Community of Belgium, Lithuania, and

Luxembourg, the central government procures access to *Microsoft Office 365* licences for everyone enrolled in the education system, including school principals, teachers, and students. It is sometimes a legacy of the COVID-19 crisis and of the urge to maintain contact with students during school closures, through *Microsoft Teams* for instance. System management tools, when they are not publicly owned by the central government but acquired from commercial providers, are also purchased through procurement conducted at the central level. This is notably the case of the student information system (SIS) in 7 countries out of 29 for which we have comparative information. School management tools, however, are more often procured by sub-governmental authorities, or schools themselves. For instance, commercial learning management systems (LMS) are procured by public authorities for the schools they are responsible for in 10 countries, including several Canadian provinces and territories, US districts and Nordic municipalities; and by schools themselves in 14 countries (see (Vincent-Lancrin, 2023[12])).

Among the 21 countries that centrally procure digital tools and resources, several have a mostly centralised procurement, either because central governments hold the greatest responsibility for the provision and maintenance of digital infrastructure in education, or because schools are not incentivised through (financial) support or guidance to procure their own tools and resources. Typically, they are the more centralised (e.g., Hungary) or the smaller (e.g., Iceland) education systems.

In Hungary, the ministry of education and its specialised agencies play a significant role in the provision and support of digital tools and resources to primary and secondary schools, in line with its central role in the education system. Schools are free to procure their own tools and resources until a certain price, but more expensive acquisitions are the responsibility of their respective maintainers. To support them, the Klebelsberg Centre aggregates school district centres' demands (which were themselves aggregated from schools) and leads the procurement process for digital tools and resources requested by public primary and secondary schools. Centralising schools' demand increases their negotiation power with external provider, notably in terms of price, and benefits from a higher availability of technical competences.

In France, the government directly procures digital tools and resources that interested schools can use (or not). Procurement is generally conducted by the ministry and its agencies, such as the *CANOPÉ Network*; but other public national or regional institutions such as the *Banque des territoires* ("the regional bank") may also fulfil that role. The French government procures digital tools and resources from external partners to complement the ones it publicly develops and provides. For instance, in 2016 a public tender resulted in the development of several *Banks of Educational Digital Resources for School* (BRNE) by French publishers and EdTech companies. The BRNE provide access to thousands of digital teaching and learning resources, tools for creation, and services for dissemination and interaction between teachers and students. Thanks to the strong relationships developed between the ministry and contractors during the procurement phase, publishers were able to fully align the BRNE's pedagogical content with the French national curriculum in all disciplines and grades.

However, this does not prevent schools in France to procure their own digital solutions as well. Recent projects such as the resource account ("*compte ressources*") sought to give schools (and teachers) more autonomy to procure additional digital tools and resources at their discretion – or at the discretion of their local authorities, in the case of primary schools. To accompany schools in their procurement choices, the ministry has set up the *Gestionnaire d'Accès aux Ressources Numériques* ("Digital Resources Access Manager", or GAR), a publicly operated interface between schools and EdTech providers. Through this interface, the ministry imposes criteria on the purchase of digital solutions and resources with regard to equity of access, interoperability, and security; and it delivers a security label to resources provided by EdTech firms on the *GAR* catalogue. In addition to guiding and procurement criteria, the ministry provides general guidance to schools related to their procurement practices.[1]

Centralising procurement practices can reduce the complexity and risks associated with procurement, improve efficiency via economies of scale, and ensure systems are interoperable (OECD, 2023[9]). A centralised strategy may also be suitable when institutions have low internal capacity and resources to dedicate to a procurement strategy. However, in institutions that can build that capacity, centralised services can be perceived as rigid, slow and unable to tackle requests not prioritised in the national agenda (OECD, 2021[13]).

Guiding decentralised procurement choices: ex-ante and ad-hoc approvals

A second, semi-centralised approach to procurement is observed in countries that publicly provide or procure some digital tools and resources centrally but also allow and support schools to procure their own, pending government approval. This is typically the case in Nordic countries, where the governance of the education system is shared between the central government and local authorities; or in countries where schools have a certain degree of autonomy to procure their own solutions in line with the central government's supervision.

Countries typically resort to two mechanisms to control schools' procurement choices. They can pre-approve lists of digital tools from which schools are free to choose from (*ex-ante*); or they can grant permission to schools for the use of a specific tools on a case-by-case basis (*ad-hoc*); or both. Out of 29 countries and jurisdictions for which we have comparative information, nine (almost a third) have lists of pre-approved digital tools from which schools are free to choose from, sometimes instead of the publicly provided tools; and seven grant permission to schools before they purchase specific digital tools or resources. Two of them (Denmark and Italy) resort to both *ex-ante* and *ad-hoc* mechanisms – although this is conducted collectively by municipalities in Denmark. Countries and jurisdictions that want to guide schools' procurement choices without actively controlling them can enact criteria on procurement, as detailed in the next section.

Denmark provides a good illustration of the Nordic countries' approach. The Danish ministry devolves the procurement of digital tools to municipalities. Municipalities are provided with central funding and with a list of pre-approved tools to choose from to equip their schools. When schools themselves want (or need) to acquire digital solutions, the *Statens og Kommunernes Indkøbsservice A/S* (SKI, or "State and Municipal Purchasing Service") grants permission on a case-by-case basis through it is a *305 taten sog* digital platform.[2] SKI is an agency mandated by the government to streamline and professionalise public procurement across sectors, including education. It was founded in 1994 as a limited company and co-owned by the Danish government and Local Government Denmark. Out of the approximately EUR 49 billion that the Danish public sector spends every year to purchase goods and services from private companies, 2.5% are channelled through SKI. In education as in other sectors, the platform's objective is to secure good quality products and services at better prices and conditions than each individual public organisation (e.g., single schools) can obtain alone. At the local level, KOMBIT, the municipalities' joint IT organisation, provides municipalities with further guidance on the procurement of digital tools and resources and help them negotiate with vendors for better prices and quality.

In Italy, the ministry facilitates schools' access to digital tools and resources through a centralised procurement application called *Protocolli In Rete*. The application is accessible via the SIDI platform (*Sistema Informativo Dell'Istruzione*, Italy's student information system) and enables schools to browse among and choose private tools approved by the ministry, as well as to apply for ministry funding for specific projects detailed in Italy's most recent digital education strategy *(Piano Nazionale Scuola Digitale*). Private providers use the same application to obtain ministry approval and make available their goods and services to schools.

Supporting decentralised procurement choices: assistance and guidance

More decentralised procurement practices may enable schools (or school districts) to usually benefit from flexibility in choosing tools and resources aligned with their specific needs. However, they also entail higher sales costs for companies, more difficulties to navigate a variety of procurement procedures and fewer opportunities for companies to scale as demand remains fragmented (OECD, 2023[9]).

In countries where schools (and teachers) operate with a larger degree of autonomy from the central or local governments, schools (and to a lesser extent teachers) are typically free to purchase the digital solutions that they want. They may nonetheless receive support or guidance from the government. Indeed, taking responsibility for the acquisition of digital education infrastructure requires schools to have sufficient information, capacity and skills to navigate a wealth of education technologies products, services and tools, as well as an understanding of procurement procedures to make effective choices (OECD, 2023[9]). While devolving procurement to schools presents the advantage of meeting each school needs in the construction of their own consistent digital ecosystem, it must come with proper guidance or schools may end up acquiring technology that requires too much IT support or is too complex to use. leading to under-utilisation. At the same time, decentralising procurement releases central government from the need for continuous investment to avoid rapid obsolescence. Indeed, 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[14]). Ensuring sufficient access to digital equipment and tools requires anticipating investment needs before shortages and inadequacies arise, which schools and end-users may be more prone to detect than central governments.

Out of 29 countries/jurisdictions for which we have comparative information, 15 negotiate the prices of digital solutions with EdTech suppliers on behalf of schools, typically to place larger orders to negotiate lower prices and more favourable contractual conditions. In Lithuania for instance, while schools and teachers have full autonomy to procure digital tools and resources, the ministry assists them in all medium-to-large sized procurements. Together with the Central Procurement Agency, the ministry negotiates with suppliers the price and contractual conditions of the digital solutions that schools want to acquire through grants, financial incentives, or non-earmarked subsidies (schools' operational budget in the case of publicly funded schools). The ministry also published lists of recommended – rather than pre-authorised – solutions for schools to choose from as well as general guidance on procurement processes.

Indeed, even if not involved in price negotiation, governments can support school procurement choices by offering guidance. Out of 29 countries/jurisdictions for which we have comparative information, 21 provide schools with national/central guidance on the procurement of digital tools and resources, including with legal brochures, step-by-step guides, dedicated platforms, and recommended resources. In countries where procurement practices are at least partly decentralised, guidance on the "how" to procure is common. Guidance on the "what" to procure, however, is less prevalent.

Often, procurement guidance comes from distinct governance levels within the education system. In Sweden, while municipalities, schools and teachers are granted full autonomy to procure digital tools and resources, the central government supports them in various ways. First, it provides municipalities with funding to complement the budget they raise from local taxes – although this funding is not earmarked for the acquisition of digital infrastructure. Second, when schools or teachers themselves want to purchase additional digital tools with their operational budget, they receive general guidance from the ministry's National Agency for Public Procurement and the Swedish Association of Local Authorities and Regions (SALAR). The former provides general support and explanations around the rules and regulations for public procurement as framed in the *Act on Systems of Choice* ("LOV"), while the latter offers more specific support to schools and teachers within the framework of the School Digitalisation Support initiative (*Skoldigistöd*), in the form of customer support and seminars for successful procurement of digital solutions.[3] As part of this initiative, SALAR has collaborated with two limited companies wholly owned by Swedish regions and municipalities (*Adda* and *Inera*) whose missions are to offer business and digitalisation support for the public sector. This collaboration was overseen by the Swedish National Agency for Education. Beyond support for procurement, the initiative aims to support and guide school principals towards the objectives outlined by the 2017 National Digital Strategy for the School System, in particular as regards access to digital resources and school development. SALAR's support to municipalities also focused on the issue of *lock-in* effects related to procurement practices, raising awareness on both the benefits and drawbacks associated with building a local digital ecosystem with tools and resources from a limited number of providers. Recent discussions have focused on finding the right balance between integration, interoperability, and the technical *lock-ins* that such a unified system may create, making the use of alternative tools increasingly intricate.[4] Finland follows a similarly decentralised approach to procurement, even though Finnish schools receive a larger portion of their budget from the central government compared to Sweden. Finnish municipalities procure tools for school management and resources for teaching and learning. The ministry provides municipalities with non-earmarked subsidies to conduct those procurement as per the central acts on public contracts. The ministry and the Association of Finnish Local and Regional Authorities jointly maintain the Public Procurement Advisory Unit, whose role is to provide contracting authorities at a lower level of government (i.e. municipalities in education) with information and advice on the application of procurement legislation.

Establishing information platforms on procurement frameworks, EdTech providers and available tools and resources is one solution to bridge the information gaps between different levels of governance (from the central government to single schools and teachers). In England (United Kingdom) for instance, the Department for Education's school procurement guidance service explains the benefits of using existing framework contracts, proposes cost-efficient alternatives based on feedback from schools and supports compliance with the relevant procurement regulations (Gov.uk, 2022[15]; OECD, 2023[9]). In addition, the government provides schools with digital and technology guidelines and is developing a tool to help schools to benchmark themselves and to identify technologies they should have in place (Department for Education, 2022[16]). In the Netherlands, given the decentralised structure and high educational autonomy of schools, the government does not enact criteria for procuring digital infrastructure. Nonetheless, to support the use of various private tools and resources that schools may acquire, Kennisnet, a government's public agency, has developed a step-by-step school guide to choosing digital learning resources, and, together with school boards, created a database called the Catalogue Information Connection Point (*Koppelpunt Catalogusinformatie*), which provides schools with a comprehensive overview of available digital learning resources. Schools can also join *SIVON*, the cooperative of school boards for procuring educational resources, exchanging knowledge and expertise, collectively organising demand bundling, jointly purchasing ICT facilities, and ensuring favourable conditions in price-quality of ICT products and services for schools.[5]

Box 12.2. Procurement strategies in federal countries

Austria

In Austria, the federal ministry of education supplements publicly provided digital tools and resources with several publicly procured commercial licensed software, such as *Google Classroom* and *Microsoft Teams*. The Austrian Federal Procurement Agency (*Bundesbeschaffungsgesellschaft* or GmbH), an agency in charge of procurement for the federal government departments, also supports the tendering processes for schools, by providing provincial and municipal governments with guidelines on the procurement of educational solutions and resources.

The ministry also supports schools in acquiring digital tools as well as teaching and learning resources through quality assurance with the Learning Apps seal of approval (*Gütesiegel Lern-Apps*). This is a quality certificate awarded by the federal ministry of education, science and research for digital mobile learning apps (and their web versions). Obtaining the certificate requires the fulfilment of set quality criteria and positive evaluation by teachers according to pedagogical, functional, and student-oriented aspects. With the certification comes an authorisation for companies to use the *Learning-Apps* quality seal on their website. The certificate is intended to provide teachers, students and parents with guidance and assistance in selecting innovative products from the market.

Canada

In Canada, while schools and teachers have autonomy to procure digital tools and resources at their discretion, provincial and territorial education authorities support them in the process in various ways. Most provincial and territorial governments directly procure digital tools on behalf of schools using the leverage of larger orders to negotiate lower prices and more favourable contractual conditions with suppliers. Among them, some provinces and territories have mandated regional organisations to handle digital procurement in education, such as *Service New Brunswick*, Saskatchewan's *Electronics Partnership* programme, or *Focused Education Resources* in British Columbia.

Brazil

In Brazil, schools operate with some autonomy regarding their choice of digital educational resources. Their procurement commonly conducted by states, municipalities or other stakeholders maintaining school networks.

However, the federal government provides a pre-approved selection of digital textbooks through its PNLD programme, which, given its size, allows for significant leverage when negotiating prices with suppliers. In the same vein, the scale of the Brazilian education system also allows the federal, state or particularly large municipal governments to broker favourable conditions for the use of digital solutions in schools, and, for example, negotiated national agreements with *Microsoft* and *Google*. In addition to the efforts aimed at all states, the federal government provides guidance on procurement processes conducted at the sub-national levels by states, municipalities or privately-run institutions willing to procure solutions with public discretionary funds.

Mexico

In Mexico, the federal government provides earmarked subsidies for the adoption of specific digital solutions. Furthermore, it has mandated organisations to foster the use of pre-approved digital solutions across the country, to establish lists of approved suppliers, and to provide legal frameworks for procurement contracts. At the federal level, the *Coordinación de Estrategia Digital Nacional* ("National digital strategy co-ordination", or CEDN) reviews and approves all federal government projects that involve information and digital technology.

Governments do and should use procurement to shape their digital ecosystem

Countries do and should use procurement to shape the nature of digital education tools and resources available to administrators, schools, teachers, students, and parents. Governments may decide on their own what can be publicly procured, but they can also guide, regulate, influence, or incentivise other public and private stakeholders' procurement choices (see Table 12.1). This section compares how countries use different procurement levers to guide both central and local procurement practices and drive changes and innovation in their preferred directions, notably restrictive criteria to publicly purchase tools and resources.

To ensure data protection and security

In most cases, countries enact restrictive criteria to ensure that procured tools and resources meet their data protection and privacy regulation as well as certain cyber-security standards.

In France, the ministry uses the *Gestionnaire d'Accès aux Ressources Numériques* (GAR, Digital Resources Access Manager), a publicly operated interface between schools and EdTech providers, to ensure a certain level of cyber-security for schools' purchases. For instance, the ministry delivers a security label to resources provided by EdTech firms that meet the technical requirements to be on the GAR catalogue. The government funds individuals' and organisations' development projects if their digital resources they meet certain eligibility criteria, one of them being compliance with data protection and privacy rules. Through the GAR, France also imposes procurement criteria regarding equity of access (resources must be accessible for students with special needs) and interoperability (some interoperability standards must be respected).

Denmark expands its digital education ecosystem by providing municipalities with funding as agreed upon by the 2015 User Portal Initiative, and sometimes with a list of pre-approved solutions to choose from. When schools want (or need) to equip themselves with their own digital tools and resources, SKI (the agency in charge of municipal procurement) may grant permission on a case by case basis. In the latter case, the ministry imposes criteria with regard to security as enacted in the *Systemrevisionsbekendtgørelsen*, a 2021 legal order on requirements for digital tools used in education. This showcases how countries can ensure that schools use tools and resources that comply with national data protection and security measures without necessarily taking responsibility for their provision or procurement.

To improve interoperability

In all surveyed countries, education stakeholders have access to a mix of publicly and privately provided digital tools and resources. Ensuring a minimal level of interoperability between various tools and resources so that they can interact, exchange data, and function harmoniously is a key policy objective in most countries (see (Vincent-Lancrin and González-Sancho, 2023[17]) for more on the interoperability of digital ecosystems). Ensuring that tools and resources follow certain interoperability principles during the procurement process, whether centrally or locally managed, is one way to embed interoperability features into digital tools and resources.

Government incentives (through rules or guidelines) are most often placed on the demand side, by encouraging (or requiring) education stakeholders to choose tools and resources that are pre-approved or by imposing explicit interoperability criteria on public procurement. In the Northwest Territories (Canada), the territorial government recommends that schools consider data interoperability in their procurement processes; in Latvia, central guidelines for public procurement in the field of ICT feature interoperability as one of the key elements to consider when digital technologies and resources are procured.[6]

But incentives could also be placed on the supply side, as it is the case to pursue other objectives than interoperability. In Finland, Finnish EdTech companies are incentivised to embed *MPASSid*, the national single sign-on (SSO) service, into their products. There is no formal or regulatory criterion, but it has become a standard practice. Similar practices could incentivise national EdTech companies to develop and sell products that are interoperable with the rest of the country's digital ecosystem.

To foster equity and inclusivity

Governments can leverage public procurement and regulate local procurement to promote equitable (or minimal) access to digital education infrastructure, reduce digital divides, and foster inclusion. As of 2024, such efforts were mainly aimed at the latter objective. Some countries and jurisdictions have laws that impose schools to procure digital tools and resources that can be accessible to everyone, inclusive of students with special needs. When not possible in practice, then an alternative should be provided.

In the Flemish community of Belgium, the ministry of education provides schools with a mix of earmarked and non-earmarked subsidies. Earmarked subsidies are channelled through the *Digisprong* action plan and are meant to cover the acquisition of digital resources for teaching and learning, while non-earmarked subsidies (i.e. schools' operational budget) can be spent on any types of resources. With those subsidies, schools have the autonomy to procure digital tools and resources on their own. Nonetheless, the ministry provides procurement guidance and has circulated non-binding criteria on schools' purchases, among which one relates to equity of access, and in particular accessibility for students with special needs. With the Digisprong funding, schools are explicitly invited to purchase ICT equipment as well as digital tools and resources that can support students with special needs (e.g. an adapted keyboard or mouse). In case of one-to-one programmes in schools that procure one laptop per student, Digisprong also recommends to prefer loan arrangements (with no deposit) for students from lower socio-economic backgrounds, rather than upfront payment.[7]

A similar procurement policy exists in the United States. States and school districts have full autonomy in their procurement choices and how much digital tools and resources they decide to provide, which can in principle lead to very differing access to technology across schools. However, they have to provide equitable access for students with disabilities, as required by the Individuals with Disabilities Education Act (IDEA). They also have to meet the security and privacy obligations of the Family Educational Rights and Privacy Act (FERPA), the Children's Internet Protection Act (CIPA), and the Children's Online Privacy Protection Rule (COPPA).

Box 12.3. Procuring digital devices through leasing

Luxembourg

In Luxembourg, a public *one2one* programme enables secondary schools to provide access to one tablet per student in the secondary classes that choose to opt in. In such classes, students can lease a tablet for a low price (and for a further reduced price if they come from a disadvantaged socio-economic background). The *one2one* programme has gained traction since its introduction in 2018, reaching more than 40% of secondary school students as of 2021.[8] The optionality of the Luxembourg's *one2one* programme makes it more efficient and tailored to local needs while providing equal opportunities to classes (if not individuals).

Japan

The Japanese government has undertaken several efforts to enhance digital equity. Since 2019, a JPY 481.9 billion (USD 3.2 billion) investment has been made for the GIGA school digital learning programme, with a view to ensuring that students have access to digital education in a sustained and equitable way. As part of the GIGA programme, all students in compulsory education (primary and lower secondary) are offered a digital device (tablet or laptop) on a 5-year lease. For students with special educational needs and disabilities, assistive technologies are also offered, such as braille display, speech-to-text technology, or eye gaze system.[9] The ministry is also promoting the distribution of devices to students in upper secondary education, aiming to ensure that all upper secondary students will have received a device by 2024.[10]

The funding for the GIGA programme comes from the central government. Yet, making the actual choice of a digital device for students falls under the remit of municipalities (for primary and lower secondary schools) and prefectures (for upper secondary schools), reflecting varying regional priorities. On these publicly procured digital devices, students can access educational resources, such as learning management systems (e.g. *Manabi Pocket*) and *MEXCBT*, a digital self-assessment system. While procuring a device to students is not mandatory, all local governments have opted to do so, creating a level playing field in terms of access to digital devices.

To make sure schools acquire effective tools and resources

Finally, a less prevalent type of criteria placed on procurement decisions in education may be enacted to require schools to acquire tools and resources whose effectiveness has been evidenced, in terms of technology capacity (e.g. the accuracy of its diagnosis, its prediction power) or as regards its effects on learning outcomes. This type of procurement policy is common practice in the health sector for instance.

None of the 29 jurisdictions that took part in our 2024 data collection have enacted such criteria. Evidence of effectiveness of digital technology is scarce, often restricted to specific context, and still ill-defined, which might make it difficult to limit procurement choices to tools and resources whose effectiveness has been proven. In some countries, option for allegedly effective tools and resources is nonetheless advanced as a decisive factor to consider when procuring digital technology.

In the United States, the federal government attaches evidence requirements for digital tools and resources procured with some federal funds within states, districts, and schools. Priority should indeed be given to *Every Student Succeeds Act*'s definition of "evidence-based" resources, which defines evidence according to a continuum between "promising" and "proven" by a randomised control trial. The Office of Educational Technology, which offers guidance on procurement of educational technologies, has developed an *EdTech*

Evidence Toolkit to help local education authorities prioritise evidence-based decisions on the adoption and use of educational technology in schools.[11]

In Hungary, the Digital Governmental Agency (DKÜ) placed under the cabinet of the Prime Ministry is in charge of unifying and harmonising IT procurement processes across sectors, including in education. Along with price and compatibility with commonly used tools and resources, DKÜ encourage schools to integrate the effectiveness of the product they want to procure as a decisive factor. Although DKÜ itself does not negotiate prices, it nonetheless regulates the amount of latitude procuring institutions can have when negotiating in each process.

Summary: key insights, reflection, and possible trends

Procurement strategies in digital education

Countries leverage multiple procurement strategies, usually according to their models of provision and governance of digital infrastructure in education. In the more centralised education systems, governments tend to directly procure digital tools for system and school management and sometimes resources for teaching and learning. In the more decentralised education systems, governments tend to leave this decision to lower level of governments (down to schools themselves) while providing guidance on *how* to procure, and more occasionally on *what* to procure. Across the board, some countries and jurisdictions issue regulation, deliver ex-ante or ad-hoc approbations, enact binding or non-binding procurement criteria, and provide dedicated support.

Those approaches are not mutually exclusive, and many countries resort to several of those levers to shape their digital ecosystem in education. As of 2024, most public efforts to guide, support or regulate decentralised procurement choices focus on economies of scales and ensuring security and compliance with data protection regulation. Some governments have also thrived to foster interoperability between the various digital tools and resources available in their ecosystem by issuing pre-authorised lists of products to procure or by setting requirements on the integration of interoperability features into external products (e.g. single sign-on systems). Only a handful of countries for which we collected comparative information have made explicit efforts to foster equity and inclusivity, or to ensure that lower levels of government (or schools themselves) procure digital tools and resources that are considered effective (e.g. evidenced positive impact on learning outcomes) and sustainable.

Data collected on countries and jurisdictions' procurement strategies suggest that most governments tend not to interfere in procurement choices of end purchasers when it comes to digital education tools and resources. Most regulation is procedural rather than substantive. In most countries, only a limited share of the digital education ecosystem is directly provided by the central or federal government, including through public procurement. For the remaining part, local governments, school districts and schools generally make their own procurement decisions in autonomy. Countries have thus adopted flexible procurement approaches. Most countries do not actively guide decentralised procurement choices, let alone impose criteria or restrictions on the digital tools and resources that schools may purchase.

This follows their regular public policies on procurement. While this could be different for education technology products that are sometimes more expensive than most education materials, these policies may relate to the very nature of education technology and the EdTech market. First, technology and educational needs are continuously evolving, making it challenging to set rigid standards that accommodate future innovations. Second, imposing binding criteria on procurement can create high barriers to entry for external EdTech providers, limiting competition and stifling innovation within the market. Smaller or emerging EdTech companies might struggle to meet these criteria, hindering their ability to participate in procurement processes. This limited competition could lead to monopolistic situations among a few established providers, reducing choices for educational institutions and potentially driving costs up. Procuring products for the same reduced set of providers may also lead to vendor lock-in effects, which make the use of alternative tools and resources increasingly difficult.

Depending on the vibrancy of their EdTech industry or the stakes and policy priorities related to certain types of digital tools, public governments may leverage more actively procurement practices to ensure alignment with specific security, interoperability, equity, and effectiveness targets within their digital education ecosystems. More and more governments may establish specific requirements and standards that promote interoperability, ensuring that various digital tools can integrate and exchange data effectively. Other governments may prioritise equity by encouraging the procurement of technologies that bridge the digital divide, providing equal access to educational resources for all students, regardless of their socio-economic background. Lastly, effective procurement practices enable governments to select tools and services that align with their educational goals, ensuring the overall efficiency and success of digital initiatives in the education sector.

Aligning procurement strategies with governance models and policy objectives

In terms of digital infrastructure, countries should aim to align procurement strategies with their governance models and the degree of institutional budgetary autonomy. A centralised strategy may be more suitable when lower levels of government (and schools) have low internal capacity and resources to dedicate to their procurement choices. Centralising procurement practices can reduce the complexity and risks associated with procurement, improve scale economies and cost-efficiency, and ensure systems are interoperable (among other things). More decentralised procurement practices may enable schools (or school districts) that have the necessary capacity to benefit from flexibility in choosing tools and resources aligned with their specific needs. However, 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.

In most countries, the procurement practices follow the usual devolution of responsibilities within the education system, often justified by legal reasons and sometimes by habit. This need not be the case. For some digital tools and resources, countries may consider using a different model than the one they are used to. It depends on many factors, including the objectives that they want to meet: equality of access; quality of the education technology offer; further integrating the system; avoiding the purchase of inefficient tools; etc. This may require an amendment to their legislation or their habits.

Some countries have a dual model of publicly providing a central or jurisdictional tool and allowing the purchase of a similar tool with public funds by sub-governmental authorities or schools. This is an interesting model. While it could be seen as duplicative of efforts and a waste of public resources, it does have the advantage of providing all schools with a free-of-charge “minimal” digital infrastructure. It also has the advantage of providing some choice, building some level of technology competence within public ministries/agencies.

Regardless of the approaches taken, countries should seek to establish good public-private partnerships and spaces for collaboration between schools and the EdTech sector. As of 2024, procurement practices, whether centralised or decentralised, are geared to optimise value-for-money. By providing support and guidance, appointing procurement agencies, establishing standards, guidelines, or binding criteria, countries could use procurement as another policy lever to shape effective digital education ecosystems.

References

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

Department for Education (2022), *Meeting digital and technology standards in schools and colleges*, https://www.gov.uk/guidance/meeting-digital-and-technology-standards-in-schools-and-colleges (accessed on 3 April 2023). [16]

Escueta, M.; V. Quan; A.J. Nickow and P. Oreopoulos (2017), “Education Technology: An Evidence-Based Review”, http://www.nber.org/papers/w23744. [7]

European Commission, D. (2023), *Digital education content in the EU – State of play and policy options – Final report*, https://doi.org/10.2766/682645. [11]

Fragoso, T. (2023), “Hardware: the provision of connectivity and digital devices”, in *OECD Digital Education Outlook 2023. Towards an Effective Digital Education Ecosystem*, OECD Publishing, https://doi.org/10.1787/c74f03de-en. [2]

Gov.uk (2022), *Guidance: Find a DfE-approved framework for your school*, https://www.gov.uk/guidance/find-a-dfe-approved-framework-for-your-school (accessed on March 2022). [15]

HolonIQ (2021), *Global Education Technology in 10 Charts*, http://www.holoniq.com (accessed on 7 April 2022). [6]

HolonIQ (2020), *Global EdTech market to reach $404B by 2025 - 16.3% CAGR*, https://www.holoniq.com/notes/global-education-technology-market-to-reach-404b-by-2025/ (accessed on 10 August 2020). [5]

OECD (2023), *Country Digital Education Ecosystems and Governance. A companion to Digital Education Outlook 2023*, OECD Publishing, https://doi.org/10.1787/906134d4-en. [10]

OECD (2023), *Government at a Glance 2023*, OECD Publishing, https://doi.org/10.1787/3d5c5d31-en. [4]

OECD (2023), *Shaping Digital Education: Enabling Factors for Quality, Equity and Efficiency*, OECD Publishing, Paris, https://doi.org/10.1787/bac4dc9f-en. [9]

OECD (2022), *Access to computers from home*, https://data.oecd.org/ict/access-to-computers-from-home.htm (accessed on March 2022). [14]

OECD (2021), “Life cycle perspective in infrastructure procurement”, in *Government at a Glance 2021*, OECD Publishing, Paris, https://doi.org/10.1787/d0865aa8-en. [3]

OECD (2021), *Supporting the Digital Transformation of Higher Education in Hungary*, Higher Education, OECD Publishing, Paris, https://doi.org/10.1787/d30ab43f-en. [13]

OECD (2009), *OECD Principles for Integrity in Public Procurement*, OECD Publishing, Paris, https://doi.org/10.1787/9789264056527-en. [1]

Vincent-Lancrin, S. (2023), “Learning management systems and other digital tools for system and institutional management”, in *OECD Digital Education Outlook 2023. Towards an Effective Digital Education Ecosystem*, OECD Publishing, https://doi.org/10.1787/c74f03de-en. [12]

Vincent-Lancrin, S. and C. González-Sancho (2023), “Interoperability: unifying and maximising data reuse within digital education ecosystems”, in *OECD Digital Education Outlook 2023. Towards an Effective Digital Education Ecosystem*, OECD Publishing, https://doi.org/10.1787/c74f03de-en. [17]

Notes

[1] In France: The GAR: https://gar.education.fr/; GAR members: https://gar.education.fr/partenaires-gar/; Procurement guidance: https://eduscol.education.fr/211/acquerir-des-ressources-numeriques-pour-l-ecole

[2] Sweden: In this case, the ministry imposes criteria with regard to security as per Systemrevisionsbekendtgørelsen, a 2021 legal order on requirements for digital solutions used in education.

[3] Sweden: Guidance on procurement at the municipal level: https://skr.se/skr/skolakulturfritid/forskolagrundochgymnasieskola/digitaliseringskola/skoldigistod/stodforupphandlingtekniskalosningarochinfrastruktursamtforpedagogiskochteknisksupport.57678.html

[4] Interoperability and lock-ins effect in Sweden: https://www.edu-digitalinequality.org/2021/04/15/interoperability-in-sweden/

[5] Kennisnet: https://www.kennisnet.nl/. The cooperative and councils include: SIVON (cooperative of schoolboards for procuring [digital] educational resources, https://sivon.nl/);

[6] Canada: https://www.alberta.ca/contract-opportunities-with-the-government-of-alberta
Latvia: https://www.iub.gov.lv/lv/jaunums/izstradatas-publisko-iepirkumu-vadlinijas-informacijas-un-komunikacijas-tehnologiju-joma

[7] Belgium Fl.: The other two non-binding criteria relate to security and safe management and to environmental sustainability. Circular letter that recommends to consider students with special needs in schools’ purchase: https://data-onderwijs.vlaanderen.be/edulex/document.aspx?docid=15855#6

[8] One2one programme: https://portal.education.lu/cgie/INNOVATION/ONE2ONE; Uptake: https://bildungsbericht.lu/fr/article/le-programme-one2one-dans-lenseignement-secondaire-au-luxembourg-dun-objectif-en-termes-dequipement-a-des-objectifs-en-termes-de-competences/

[9] MEXT does not directly fund schools themselves, but prefectures and municipalities. Then the local governments make decisions on which device they would buy

[10] https://www.mext.go.jp/content/20220324-mxt_shuukyo01-000020467_001.pdf

[11] EdTech Evidence toolkit: https://tech.ed.gov/evidence/

13 Multi-stakeholder collaboration and co-creation: towards responsible application of AI in education

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This chapter discusses the importance of cooperation and co-creation in innovative networks to develop and understand responsible, social and ethical application of AI in education. In order to drive innovation in the field of education, two important components are the involvement of multiple actors and a dynamic innovation process. These components are connected by a shared language that ties the interaction between different actors: educational professionals, scientists, and entrepreneurs. This chapter outlines how triple helix innovation models and a common language can advance the utility of AI in education. Different partnership models for multi-stakeholder contribution and co-creation and evolving globally through innovation labs and expertise centres. We describe a number of these partnership to understand how they contribute to innovative AI technologies for education and to responsible use of AI in education. Comparing these approaches gives an overview of current initiatives and provides insights into how these partnerships work in practice. This chapter will support governments and NGOs to inform future policy for innovation labs that drive towards transformative development of the education sector.

Introduction

There are few moments in history when artificial intelligence (AI) in education has been more in the news than November 2022 after the release of ChatGPT 3.5 (Kasneci et al., 2023[1]). Many questions were raised by schools and in ample public debates, the use of generative AI in education was the subject of discussion. This contributed to a broad awareness that AI may impact our lives substantially and will lead to changes in work, social interaction and schooling as predicted by policymakers in numerous reports, for example from OECD (2019[2]) and NESTA[1]. How profound this impact will be is hard question to answer. AI will clearly take over specific tasks for humans and increasingly play a role in our day to day activities. Harvard professor Chris Dede suggests that AI is especially good at reckoning, fast data analysis and pattern recognition. The opportunities provided by AI systems lie in fast collection of data, diagnostics, and enactment, enabling the personalisation of education (Holmes et al., 2018[3]; Molenaar, 2022[4]; OECD, 2021[5]). According to Dieterle, Dede and Walker (2022[6]), humans are good at judgement. Their added value lies in social-emotional considerations, connecting new elements, problem-solving abilities, and social reasoning. These human skills are beyond AI's current abilities and will become increasingly important. This raises the question of what we should *educate for* and what it means for the way we use AI in education.

Research and development around AI have only slowly reached educational institutions. Innovation of AI in education is concentrated in separate communities and takes place in isolated worlds. Scientific dialogue and exchange is taking place in different scientific societies, such as the International Artificial Intelligence in Education Society (IAIED, https://iaied.org/about), the Society of Learning Analytics Research (SOLAR, https://www.solaresearch.org/) and the European Association of Technology Enhanced Learning (ECTEL, https://ea-tel.eu/). Schools and educational professionals interact in national and international communities of practice, such as Kennisnet (Netherlands) and European Schoolnet (http://www.eun.org/) (EU countries) or the International Society for Technology in Education (ISTE, https://iste.org/) (United States). Companies also mostly move in their own network communities: for example publishers of education materials collaborate in the International Publishers association (IPA, https://www.internationalpublishers.org/our-work/educational-publishing/educational-publishers-forum), and start-ups and scale-ups find each other in the European Edtech Alliance (https://www.edtecheurope.org/) and other similar associations around the world. Moreover, educational professionals and institutions often lack the expertise to formulate their needs for AI technologies, despite recent efforts to support teachers and other education stakeholders to understand how to use AI (e.g. the European Commission supports several European and national projects such as the AI4T project).[2]

As a result, scientific researchers are mainly focused on fundamental research and are insufficiently able to meaningfully use the developed intelligent algorithms in the educational context. Entrepreneurs often face difficulties to connect with educational professionals and often lack hands-on educational and pedagogical expertise. In addition, the current use of AI in educational practice and scientific research on AI in education do not reflect the anticipated, longer term upward movement toward higher levels of automation between humans and artificial intelligence, levels in which AI controls most or all tasks (Molenaar, Forthcoming[7]). More targeted research is needed to fulfil future expectations about AI in education to forward the transformative development of the educational sector. Hence, the quality and speed of innovation are currently reduced by structural problems at different system levels.

This system-level fragmentation limits the possibilities for the technology to be developed in ways that are beneficial to the education community, that it aligns with its goals and values while upholding an interdisciplinary perspective on the responsible use of AI in education. Therefore, this chapter argues that cooperation and co-creation between different stakeholders in innovative networks is needed to address the challenges of AI in education and develop and evaluate meaningful AI technologies for education. This requires an innovative ecosystem around AI that encourages the co-evolution of knowledge and innovation and creates a common language for different stakeholders around AI in education.

The chapter first outlines how innovation benefits from multi-stakeholder collaboration and a dynamic approach of innovation. These elements are connected by a common language to promote and progress the dialogue about AI in education. We the present different examples of labs and expert centres from OECD countries using partnership models from the lens of multi-stakeholder collaboration and dynamic approaches to innovation. Comparing these initiatives provides insights into how these partnerships are formed and can contribute to the ecosystem needed to support innovation and the responsible use of AI in education. The chapter then provides some recommendations for possible supportive future policy initiatives.

Collaboration and co-creation as proposition to overcome silos

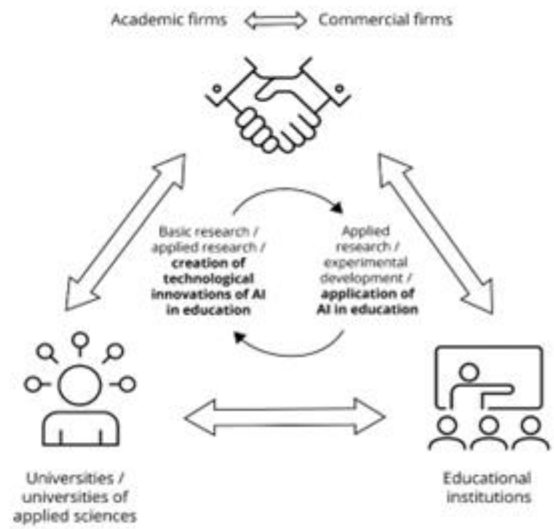
As described above, current innovation of AI in education is concentrated in separate communities and takes place in isolated worlds. Moreover, the linear model of innovation prevails (Carayannis and Campbell, 2009[8]). In this model, innovation starts with basic university research that is later converted into applied research of university-related institutions and finally transformed into experimental development and commercial market applications by firms. To address the challenges and threats of AI for education, more complex, non-linear models of innovation and dynamic processes of knowledge creation, diffusion and use are needed (Elias and E., 2016[9]; Carayannis et al., 2018[10]). In contrast to the traditional linear model of innovation, non-linear models underscore a more parallel coupling of basic research, applied research and experimental development. They emphasise the collective interaction and exchange of knowledge in hybrid innovation networks that tie together interactions between universities, commercial and academic firms and governments.

This innovative ecosystem, often referred to as the Triple Helix model, places a strong focus on cooperation in innovation and the process of co-creation of different actors from three different sub-systems: universities/science (educational sub-system), industries/firms (economic sub-system) and governments (political sub-system). The equal role of each one of these categories of actors in the development of new innovative products, services, and solutions is stressed. Carayannis and Campbell (2016[9]) have proposed to add a fourth sub-system, the civil society, to the Triple Helix model. This Quadruple helix model bridges the social ecology with knowledge production and innovation and puts innovation users (civil society) at its heart: they own and drive the innovation processes. In the case of education, this implies to engage with teachers, school principals but also students and families and appropriate.

The current departmentalisation of stakeholders does not help to drive innovation in AI in education. It is an international challenge to use the Triple Helix approach as an operational strategy to facilitate cooperation and co-creation between different stakeholders in innovative networks around AI in education. Different partnership models of innovation labs and expertise centres for co-creation and multi-stakeholder contribution have been established and are evolving around the globe. Governments may facilitate innovation labs and expert centres to foster cooperation and co-creation in hybrid innovative networks and contribute to the responsible, social and ethical application of AI in education. By encouraging the integration of different modes of knowledge creation, diffusion and use of AI in education, these innovation ecosystems will help to develop and evaluate meaningful AI arrangements that are beneficial to the education community.

Cooperation and co-creation between diverse interdisciplinary scientists, educational professionals, and entrepreneurs could lead to transformative practices, driven from a pedagogical-didactical perspective, in the development and uses of AI applications in education (see Figure 13.1).

Figure 13.1. Triple Helix Innovation in education



Source: Adapted version of conceptualisation of an innovation ecosystem as developed by Carayannis, & Campbell (2009[8]).

Including educational scientists and practitioners with a strong understanding of learning processes, AI scientists with an interdisciplinary interest in applying AI in education and philosophers and lawyers with a special interest in privacy and ethical aspects of these innovations is important.

The first step in the co-creation process is to develop a shared conceptual understanding of the educational setting in which the technology will be applied. Next, the functioning of AI in this context and consequent roles of learner, teacher and AI can be detailed. In an iterative design cycle (McKenney and Reeves, 2013[11]), developing a new technology can advance current technical and pedagogical-didactical knowledge, creating mutual understanding and further conceptualisation of the AI technology. The technological elements can then be developed, the pedagogical-didactical approach specified, and supporting materials for teachers and learners developed. User experiences in the classroom will further illuminate how technical and pedagogical-didactical innovations reinforce each other. We envision these new technological developments to materialise in collaboration between researchers and educational professionals in iterative cycles. The close integration of development and application in classroom practice may help mature AI, tune the actors' roles, and develop the interface to support reciprocal interaction. The developed AI technologies support implications and set boundaries to fit with educational norms and standards. Designing these technologies in partnership will result in new reciprocal human-AI relationships within the field of education, which is likely to be beneficial for innovation in education and enhance the understanding of hybrid human-AI relations in this context.

The final step will be to validate these new technologies with AI at scale, to assess the value for educational and to understand how they contribute to advancing learning and teaching. In this validation process, developed technologies are tested in multiple classrooms and schools to assess the learning technology applicability and suitability in multiple contexts. At the same time, effects of the technologies on learning outcomes or other learning metrics are assessed. The learning technologies are instrumented in this phase which mean that researchers can execute random control trails (RCT) or undertake other meaningful forms of research to generate robust evidence in close collaboration with schools. Also this learning engineering infrastructure can help support ongoing experiments at scale in learning technologies (Koedinger, Corbett and Perfetti, 2012[12]). This long-term partnership between research and educational institutions can both enhance technologies and forward our theoretical understanding of how AI technologies can support learning and teaching.

A common language for stakeholders

Cooperation and co-creation between diverse scientists, educational professionals, and entrepreneurs can contribute to developing a common language about AI in education. Such common language may help articulate a shared perspective on the role of AI in education and the development of hybrid human-AI arrangements.

There are many ways in which AI can contribute to education, but there is also an important difference with other application domains (Selwyn, 2019[13]; Holmes et al., 2018[3]). AI in education aims to optimise human learning and teaching in a system where human and artificial intelligences are combined in a meaningful manner (Molenaar, 2022[4]). AI in other application domains often aims at replacing humans. For example, AI will ultimately take over the human driver's role in self-driving cars. The augmentation perspective on optimising human learning and teaching comes from the notion that human intelligence and artificial intelligence have different strengths. Artificial intelligence is good at quickly collecting, analysing, and interpreting large amounts of data; humans are still better at judging, social interaction, creativity and problem-solving (Dieterle, Dede and Walker, 2022[6]).

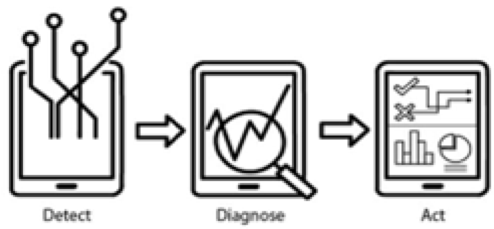
These strengths underlay the augmentation perspective on artificial intelligence (AI) in education. This perspective emphasises the role of AI in facilitating and strengthening student learning with the teacher. This differs from a replacement perspective that implicitly assumes that AI alone can optimise student learning. The augmentation perspective aligns well with the notion of hybrid intelligence, conceived as the meaningful combination of human and artificial intelligence (Akata et al., 2020[14]). In hybrid intelligence, humans and AI are considered to be team players who perform and solve tasks in collaboration. Hybrid intelligent systems aim to coordinate and supplement artificial and human intelligence so that they are stronger together than each separately. This entails that the roles of teachers, students and AI must be articulated when developing intelligent innovations. In order to understand this interaction, more insight is needed into two coherent characteristics: 1) the functioning of AI and 2) the division of roles between AI, teacher and student.

To gain more insight into these two characteristics, we discuss Molenaar's Detect-Diagnosis-Act framework (the functioning of AI), followed by the six levels of automation model (division of roles between AI, teacher and student) (Molenaar, 2022[4]). These models are the core elements of a common language that can help different stakeholders to discuss use cases of AI in education. Teachers and educational professionals can relate to this relatively simple explanation of AI and it helps them to understand different applications in the educational domain. Scientists from different disciplines can compare use cases and discuss implications from a shared understanding of the role of AI in education. Finally, the general description of technological solutions helps companies to position their product in the EdTech market.

The Detect-Diagnosis-Act framework

The detect-diagnosis-act framework distinguishes three mechanisms that underlie the functioning of AI: detect, diagnose and act (Figure 13.2).

Figure 13.2. Detect-Diagnose-Act Framework



Source: Illustration - Anne Horvers and Inge Molenaar, Source: Adaptive Learning Lab, https://www.ru.nl/bsi/research/group-pages/adaptive-learning-lab-all. (Molenaar, 2021[15]).

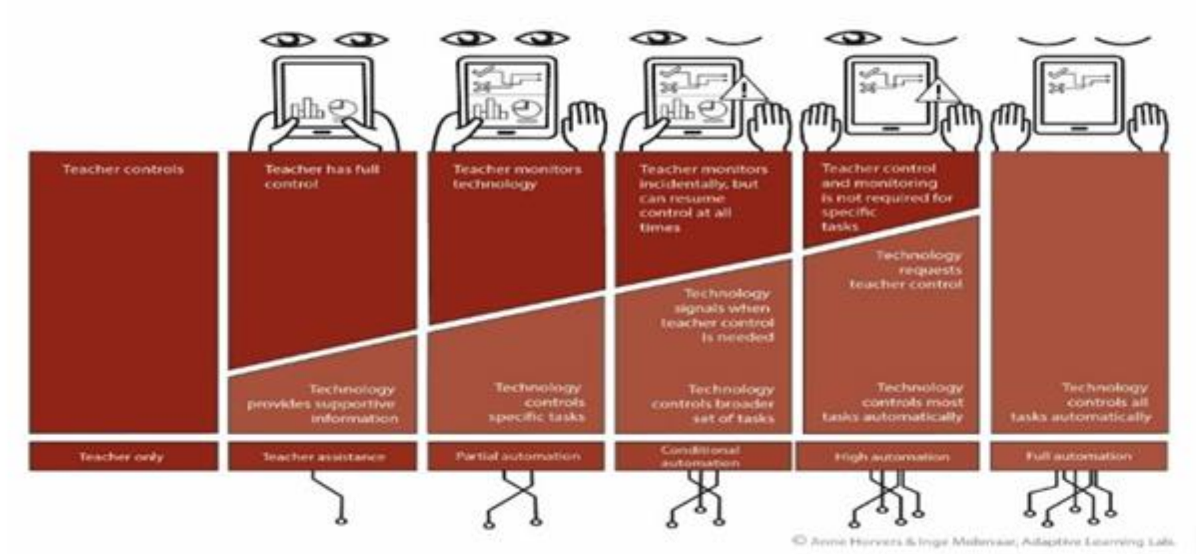
In "detect" mode, the data that the AI uses to understand the learning of the student or the teacher's teaching are made explicit. For example, many adaptive learning technologies use students' answers to measure the student understanding of a domain. In "diagnose" mode, the constructs the AI analyses to understand the learning or teaching process are outlined: this can be a student's knowledge, skills or emotions. For example, the vocabulary of a student in a foreign language or knowledge about fractures is diagnosed by the AI. Finally, the "act" mode describes how the translation from the construct measured to a didactic pedagogical (or other kind of) action is made. The system can translate the diagnosis into information, for example presented in a dashboard, or the diagnosis can lead to activities carried out by the AI, for example, the technology selects feedback for a student. This model supports a basic understanding of how AI functions among multiple types of applications for stakeholders and helps to promote and progress the discussion of the application of AI in specific technologies.

Current AI solutions for education often use log data to detect, they mostly diagnose students' knowledge in specific domains and consequently act by providing feedback, adjusting task or selecting the next topic to learn. Current technology frontiers lay in including multiple data streams in "detect" phase, such as physiological measures or contextual measures; including broader constructs of the learners in the "diagnose" phase, for example emotional development or self-regulated learning skills (Molenaar et al., 2023[16]). And finally getting toward more diverse actions patterns, including interacting with learners on multiple levels.

The six levels of automation model

Second, the division of roles between AI, teacher and student needs to be articulated. Articulating this division can be done by using the "six levels of automation model" (see Figure 13.3). This model distinguishes six different levels of automation depending on the degree of control by the teacher, the student and/or the system (Molenaar, Forthcoming[7]).

Figure 13.3. Six levels of automation model



Source: Anne Hovers and Inge Molenaar, Adaptive Learning Lab.

The model starts with full teacher control and ends with full automation, hence AI control. This model helps understand various combinations of automation between humans and artificial intelligence. For example, when teachers are assisted with data and classifications made by AI, the control remains with the teacher, but teacher's behaviour is influenced by the information from the AI. On the other hand, when students are using generative AI applications for their homework assignment, the answer is generated by the AI and without human oversight (unless students revise it or just use it as an input to their own work).

This model helps us to understand relations between AI, teachers and learners to specify requirements for the technology and the needed interface to support teachers in using the technology (Molenaar, 2022[4]). It can also help teachers to integrate the technology in pedagogical approaches to develop new teaching practices (Cijvat et al., 2022[17]; Van Schoors et al., 2023[18]). Additionally, this model can promote the dialogue between different stakeholders about AI's current and future uses in education and help build a shared perspective on the development of hybrid human-AI arrangements. It helps both understand how AI can support rather than replace human tasks and work, but also reflect on when and how humans should intervene when AI is involved.

The global landscape of innovation labs and expert centres that supports the development of AI in education around the globe

In this section, we describe eleven examples of innovation labs and expert centres. These labs are located in Europe, the United States and Australia (see Table 13.1). The represent different partnership models aimed to create multi-stakeholder collaboration and co-creation in the development of AI in education Their full description is available in Annex 13.A.[3]

This selection presents an overview of how different innovation labs and expert centres aim to make AI in education more useful to education stakeholders. Different combinations of stakeholders and innovation approaches are followed in different countries. Most of the initiatives focus on all levels of formal education (SMART@EDUCATION, Colider, TüCeDE, EDUCATE), except NOLAI and Engage that focus on primary and secondary education, and AI-ALOE that is directed at vocational, higher education, and professional development. With respect to funding, most initiatives are funded by (local) governments and universities.

Some initiatives are co-funded by industry. The amount of funding differs, ranging from EUR 1 to 90 million. Most initiatives have mid-term duration (5 years) mandates or objectives, with some long-term examples (10 years) too.

Table 13.1. Description of different innovation labs and research centres around the globe

Name[4]	Country	Partners	Goals	Category	Duration	Size
National Education Lab AI (NOLAI)	The Netherlands	Universities, School boards and Business development agencies	National expert centre that develops innovative intelligent technologies and scientific knowledge of responsible usage of AI in education with the aim to improve the quality of primary and secondary education	Schools, science and industry combined product development	2022 for 10 years	80 million 30 to 40 FTE
IMEC Smart Education	Belgium	Universities, national research and innovation hub	Strategic research and innovation programme that aims to develop state-of-the-art technologies in order to address grand challenges in education and training.	Schools, science and industry combined product development	2017 for 9 years	40 FTE 1 million seed funding
Tübingen Center for Digital Education (TüCeDE)	Germany	University departments, independent research institute	Expert centre that aim to strengthen the transfer expertise in digital education within the university and toward new teachers.	Science for Teacher Professionalization	2022 for 5 years	12.2 million 30 FTE
Engage AI Institute	USA	Universities and non-profit organisations	Research institute to deepen engagement and advance learning by creating a new class of narrative-centred learning environments in which students can collaboratively engage with customised plots, synthesised characters, and realistic forms of interaction.	Science for product development	2022 for 5 years	20 million 30-40 FTE
National Artificial Intelligence Institute in Adult Learning and Online Education (AI-ALOE)	USA	Universities, non-profit organisations and corporations	National institute to expand access to quality jobs and improving workforce reskilling and upskilling by applying the affordances of AI to transform online education for adult learners	Science for product development	2022 for 5 years	20 million 50 fete
EDUCATE Ventures Research Ltd	UK	Companies and non-profit organisations	Company that increases the effectiveness of evidence generation and application of members of the EdTech ecosystem, and to help them leverage data and AI.	Business ecosystem development and evidence-based technologies	2017 ongoing	Generates own funding 7 FTE
Swiss EdTech Collider	Switzerland	University and foundations	A not-for profit association for the long-term effort to nurture the Swiss EdTech ecosystem: create a marketplace and support business development.	Ecosystem development and evidence-based technologies	2017 ongoing	1 FTE
CELLA	International	Universities and foundation	Research centre that investigates how to equip young learners to learn, live, and work in the age of AI.	Research collaboration	2022 for 5 years	2 million 7 FTE
CIRCLS (Center for Integrative Research in Computer and Learning	USA	Universities and non-profit organisations	Research hub that interconnects separately-funded National Science Foundation research projects, each of which investigates emerging	Research collaboration		3 million + 50 funded projects

Name[4]	Country	Partners	Goals	Category	Duration	Size
Sciences, circls.org)			technology for teaching and learning.			
GRAIL	International	Universities	Research hub that connects different research centers around AI and education	Research collaboration	2022 ongoing	No direct budget
AI Playground	Australia	University, company, schools	The AI Playground offers a cloud-based learning environment for schools to help teachers offer AI learning experiences to their students.	Science and industry for product development		

Multi-stakeholder collaboration

In most initiatives, the quadruple helix actors (university, industry and educational institutions as end-users) are included and governments are part of the supporting system. The role of the actors involved clearly differs across the labs. Universities are central, with industry collaborating, and implementation end-users in educational institutions often have an implementation role (Engage, AI-ALOE, AI Playground).

The role of end-users is more central in the examples of NOLAI and IMEC Smart education, where innovation is initiated based on end-user questions and co-created with science and industry. In two labs, EDUCATE and Edtech Collider, industry is more central, with universities as a facilitating actor. TüCeDE is the only initiative in which the delivery of scientific insights to educational institutions is central. Finally a number of labs (CELLA, RCL, GRAIL) focus on scientific collaboration to support international exchange of scientific knowledge.

The governance models used in these labs represent the dynamics among the partners involved. Universities are mostly leading with EDUCATE as the exception, a spin-off company from a university. Some initiatives include independent research institutes (TüCeDE), national innovative companies (SMART@EDUCATION), non-profit organisations (Engage & AI-ALOE) or Foundations (Colider, CIRCLES & CELLA) as partners. Business development organisations lead industry-dominant labs and are partners only in other initiatives (NOLAI, IMEC smart education and AI-ALOE). Surprisingly, school boards (or education practitioners) are only represented in the governance model of NOLAI; in the other labs, schools are collaboration partners but not represented directly in the governance.

Dynamic approaches to innovation

Although each initiative has a unique focus and areas of expertise, different approaches to innovation seem to underlie the different labs.

A first approach reflects and adapts the linear approach to innovation: scientific research is translated and transformed into product development and market applications. For example, new products are developed in which AI research is leveraged, such as narrative-centred learning environments and advanced chatbots in Engage. Another example is the Cognitive Support in Manufacturing Operations project (COSMO) in IMEC smart education, which develops data-driven techniques to create content for assembly training applications in augmented and virtual reality (AR and VR). The aim is to adapt training contents to the operator's skill level. In these examples linear innovation is accelerated and enriched with industry collaboration and inclusion of end-user educational professionals.

More non-linear innovation models are also represented in these labs. For example, in AI playground, scientific understanding of children's learning is combined with new industry developments in AI processing of video observations to detect learner behaviour. This allows for new approaches to science education and teaching computational thinking. In NOLAI, questions from educational professionals are the starting point and thus central in the innovation process. These questions are translated in envisioning future use cases based on new scientific insights and novel industry developments. For example, the "happy readers" project combined the request of primary school teachers to have more insight into how students' technical reading skills develop over time with what university and industry partners know about current affordances of technology: new insights from reading research together with novel automated speech recognition algorithms developed by a start-up company can allow for new approaches to reading education.

A second approach is more geared towards industry development and aims to help start-ups to improve product (propositions) with scientific insights and enhance the ecosystem for companies to thrive and scale up. Business development activities in these initiatives are diverse: from supporting prototype development, optimising products in multiple schools, diversifying to new sectors in education, and validating the effectiveness of products to support an evidence-based development of Edtech tools and resources in schools. In labs focusing on business development, such as EDUCATE and Collider, co-creation is starting in industry, in collaboration with testbeds in schools (Collider) and by stimulating Edtech to collaborate with researchers (EDUCATE). For example, the Swiss Edtech Collider helps companies to set up testbeds in schools to support product development and enhance the dialogue with practitioners. EDUCATE also helps companies articulate a theory of change and provides a strategy dashboard to drive product development. This approach has been tested in several calls for projects with the aim to foster collaboration between Edtech, academics and teachers and pupils, for example within the European Institute of Technology's "Community AI" at the European Union level or within some countries, for example the AI innovation partnership for learning French and mathematics in France.[5] All these actions support Edtech companies to mature, grow their market by making their products more relevant to education practitioners and increase the integration of new scientific insights into product development. Again non-linear innovation modes are developed, but the focal point is the industry side.

A third approach aims to apply scientific insights to improve teacher professional development and school innovations. The pathway from university to drive innovation in educational institutions is central here. For example, TüCeDE aims to improve teachers' understanding of technology and how it can enhance learning and teaching. In implementing different EdTech tools in schools, successful and responsible usage of AI in classrooms is developed. This example represents a relatively linear innovation mode, from science to educational institutions, which are often overlooked as essential to ensure innovation in public education.

Finally, a fourth approach focuses on improving collaborations and orchestrating international research (CELLA, CIRCLS & GRAIL). These initiatives support exchanges of scientific knowledge and methods to spur scientific research in this domain. For example, in the Center for living and learning with AI (CELLA) five research groups are executing a combined research agenda to develop understanding of how to support young learners in their skill development for an AI era. Unique is the international comparative study that investigates young learners' self-regulated learning in the context of an AI-empowered learning technology, which attempts to help us identify learners' skillset that may be required to learn with AI around the globe. Consequently, industry and educational institutions can use this to develop new products and transform educational practices. This example highlights a more traditional ecosystem to spur scientific understanding and innovation.

Despite the different approaches, the initiatives mostly develop innovative technical products with AI and support transformative innovative practices in schools. Other outputs are scientific publications describing design processes, algorithms developed, and evaluation studies, including randomised control trials (RCTs). Most initiatives also create professional publications for educational professionals discussing AI in education, current developments in AI and its effects on learning and teaching.

Innovation labs and expert centres as innovation ecosystems

The different initiatives represent diverse approaches to supporting a good use of AI in education, involving different stakeholders in central positions and different dynamics to innovation. More linear approaches are combined with non-linear processes of innovation that are present in all initiatives – but the starting point and the central actor driving these processes are different across initiatives. From scientific research leading to product development with industry to driving innovations in educational institutions to spur the professional development of educational professionals. Universities play an important role with several non-profit organisations and foundations. However, there is little involvement in the leadership of schools and educational professionals in these initiatives. Involving and engaging teachers and educational professionals from the start of the co-creation process may be important to overcome the gap between science and practices and adhere to schools' needs while developing and evaluating meaningful AI arrangements in education.

Knowledge development is central in most of the initiatives, with a focus on knowledge transfer. Scientific interdisciplinary research mainly drives and supports co-creation processes aimed at developing meaningful AI arrangements in education. In order to develop state-of-the-art new prototypes, those initiatives ensure a sound basis from a pedagogical-didactical perspective, integrate knowledge from the learning sciences, and strong technological development is realised by combining computer sciences, artificial intelligence research, learning engineering and learning analytics. User studies and design-based research ensure practical usability. The involvement of educational scientists and teacher trainers focuses on proper implementation strategies in schools and other educational institutions. Involving and engaging teachers and schools right from the start of the co-creation process is important to implement meaningful AI arrangements that effectively suit education professionals' needs.

The described initiatives clearly show that a multi-stakeholder approach driving and supporting interdisciplinary collaboration and co-creation is being used to develop meaningful applications of AI in education. Collaboration of multiple stakeholders can not only facilitate an orchestrated dialogue by using a common language to discuss use cases of AI in education but can also ensure that the technology is developed and used in ways that benefit the educational community. The initiatives show promising institutionalised ways to break through the current departmentalisation of stakeholders. The challenge is to find sustained institutional ways to engage teachers/schools, scientists, industry and governments in this orchestrated dialogue, based on constructive collaboration and co-construction, and experiment different models of effective partnerships needed to drive AI's integration in the future of education.

Conclusion: where do we go from here?

In this chapter, we showed that developing and using sounds AI applications in education is a complex endeavour that needs interdisciplinary, multi-stakeholder actors to collaborate in non-linear dynamic approaches to innovation. This approach will help to overcome system-level failures related to the departmentalisation of different actors and, too often, linear approaches to innovation that ignore the end-user perspective in educational innovation. These system failures stand in the way of digital innovation in the education sector, which is problematic in the AI era. The development of hybrid human-AI technologies in the educational field can improve human learning and teaching and support the needed upskilling of humans. The need for an upward movement towards higher levels of automation in education is acknowledged by international stakeholders, but the current innovation ecosystem is insufficiently equipped to realise this task.

We argue that the advancement of AI in education can only happen in collaboration with end-users to ensure uptake and future scaling of new technologies in school. The emerging understanding of responsible use of AI in education needs an interdisciplinary scientific perspective, including learning sciences, educational psychology, teacher professionals, computer scientists, AI scientists, philosophers and embedded ethicists as well as lawyers. A highly interdisciplinary scientific field combining these disciplines could be envisioned to fully understand upskilling in the AI era and how AI in education can facilitate the transition to teaching skills for the future to young learners.

We discussed how multi-stakeholder approaches address challenges to improve developments of AI in education in a promising way. Critical components are a rich and diverse ecosystem, a common language, and active involvement of governments to drive upward progression. Different innovation labs and expert centres already explore this idea and the study of different approaches will help countries to move forward. These different initiatives address the needs of different stakeholders and make different choices a to the key focus, depending on the actor(s) in the main driving position of their innovation ecosystem. All these initiatives highlight the need for (and possibility of) capacity building in this domain to help educational institutions, industry and science to make collaborative progress. Transitional boundary crossing in multiple forms is essential to move forward and structurally rethink how we learn as humans, teach for upskilling, and how AI will affect education in a positive way.

References

Akata, Z.; D. Balliet; M. De Rijke; F. Dignum; V. Dignum; G. Eiben and M. Welling (2020), "A research agenda for hybrid intelligence: augmenting human intellect with collaborative, adaptive, responsible, and explainable artificial intelligence", *Computer*, Vol. 53/8, pp. 18-28. [14]

Carayannis, E. and D. Campbell (2009), "'Mode 3' and 'Quadruple Helix': Toward a 21st century fractal innovation ecosystem", *International Journal of Technology Management*, Vol. 46/3/4, pp. 201-234, https://doi.org/10.1504/IJTM.2009.023374. [8]

Carayannis, E.; E. Grigoroudis; D. Campbell; D. Meissner and D. Stamati (2018), "'Mode 3'universities and academic firms: thinking beyond the box trans-disciplinarity and nonlinear innovation dynamics within coopetitive entrepreneurial ecosystems", *International Journal of Technology Management*, Vol. 77/1-3, pp. 145-185. [10]

Cijvat, I.; E. Denessen; P. Sleegers and I. Molenaar (2022), "Wat leraren doen: de inzet van adaptieve leermiddelen in het basisonderwijs", *Pedagogische Studiën*, Vol. 100. [17]

Dieterle, E., C. Dede and M. Walker (2022), "The cyclical ethical effects of using artificial intelligence in education", *AI & Soc*, https://doi.org/10.1007/s00146-022-01497-w. [6]

Elias, C. and G. E. (2016), "Quadruple Innovation Helix and Smart Specialization: Knowledge Production and National Competitiveness", *Foresight and STI Governance*, Vol. 10/1, pp. 31-42, https://doi.org/10.17323/1995-459x.2016.1.31.42. [9]

Holmes, W.; S. Anastopoulou; H. Schaumburg and M. Mavrikis (2018), *Technologyenhanced Personalised Learning: Untangling the Evidence*. [3]

Kasneci, E.; K. Seßler; S. Küchemann; M. Bannert; D. Dementieva; F. Fischer; U. Gasser; G. Groh; S. Günnemann; E. Hüllermeier and S. Krusche (2023), "ChatGPT for good? On opportunities and challenges of large language models for education", *Learning and Individual Differences*, Vol. 103. [1]

Koedinger, K., A. Corbett and C. Perfetti (2012), "The Knowledge-Learning-Instruction framework: Bridging the science-practice chasm to enhance robust student learning", *Cognitive science*, Vol. 36/5, pp. 757-798. [12]

McKenney, S. and T. Reeves (2013), "Systematic review of design-based research progress: Is a little knowledge a dangerous thing?", *Educational researcher*, Vol. 42/2, pp. 97-100. [11]

Molenaar, I. (2022), "Towards hybrid human-AI learning technologies", *European Journal of Education*, Vol. 57/4, pp. 632-645, https://doi.org/10.1111/ejed.12527. [4]

Molenaar, I. (2021), “Personalisation of learning: Towards hybrid human-AI learning technologies”, in *OECD Digital Education Outlook 2021, Pushing the Frontiers with Artificial Intelligence, Blockchain and Robots*, OECD Publishing, https://doi.org/10.1787/589b283f-en. [15]

Molenaar, I. (Forthcoming), “Current status and future visions on Hybrid Human-AI learning technologies”, *British Journal of Educational Psychology*. [7]

Molenaar, I.; S. de Mooij; R. Azevedo; M. Bannert; S. Järvelä and D. Gašević (2023), “Measuring self-regulated learning and the role of AI: Five years of research using multimodal multichannel data”, *Computers in Human Behavior*, Vol. 139, https://doi.org/10.1016/j.chb.2022.107540. [16]

OECD (2021), *OECD Digital Education Outlook 2021: Pushing the Frontiers with Artificial Intelligence, Blockchain and Robots*, OECD Publishing, Paris, https://doi.org/10.1787/589b283f-en. [5]

OECD (2019), *Going Digital: Shaping Policies, Improving Lives*, OECD Publishing, Paris, https://doi.org/10.1787/9789264312012-en. [2]

Selwyn, N. (2019), *Should Robots Replace Teachers? AI and the Future of Education*, John Wiley & Sons, Inc. [13]

Van Schoors, R.; J. Elen; A. Raes and F. Depaepe (2023), “Tinkering the Teacher–Technology Nexus: The Case of Teacher-and Technology-Driven Personalisation”, *Education Sciences*, Vol. 13/4, p. 349. [18]

Annex 13.A. Descriptions of labs, expert centres and business development

National Education Lab AI (NOLAI) –The Netherlands

Partners

Strategic partners are four knowledge institutions: Radboud University, University of Utrecht and Maastricht University and HAN university of applied sciences, three schoolboards: Lucas Education, Klasse and Quadraam and two business development centres Oost.nl and Brightlands. NOLAI located at the Faculty of Social Sciences of Radboud University.

Main goals

The Dutch National Education Lab for Artificial Intelligence (NOLAI) aims to develop innovative intelligent technologies that improve the quality of primary and secondary education. The goal is to develop innovative prototypes that use artificial intelligence and develop new knowledge on responsible use of AI in education.

Size and duration

Between 30 to 40 people will be working at NOLAI and each year 10 to 20 co-creation projects are funded. The institute has an initial funding form the Dutch National Growth Fund of 80 million for the duration of 10 years and a follow reservation for business development and upscaling of evidence based prototypes of 63 million.

Focus on:

- articulation of needs with educational institutions
- co-creation of innovative use of AI in education
- business development of evidence based prototypes
- knowledge transfer and development to schools and business

Focus group:

- primary and secondary education

Description of programme

NOLAI has two main programmes: the co-creation programme and the scientific programme. The co-creation programme develops innovative prototypes and applications of AI in co-creation with schools, scientist and business. Each year 10 to 20 new innovation using AI in education will be supported in this programme. The scientific programme develops knowledge on pedagogical-didactical, technical, infrastructural and ethical aspects of responsible use of AI in education. A team of professors, post-docs and PhD develops interdisciplinary knowledge on AI in education.

Main activities

NOLAI's main activities are to investigate the state of play and develop state of the art applications. State of play: in dialogue with schools we explore what their needs are for using AI to improve education, with scientist we map current knowledge and prototype development and with business explore current application of AI products and ambitions for the future. In relation to the state of the art, we work on co-creation developing innovation prototypes and application of AI in education and we develop pedagogical and ethical knowledge and new technical innovations to support state-of-the-art application of AI in education in our scientific programme.

Outcomes

Yearly reports on the development of the field, prototypes that are developed in co-creation projects, new demonstrations of how to apply AI in pedagogical arrangements, evidence of the effectiveness of AI in education, new pedagogical and ethical knowledge, technical developments and publications as outcomes of interdisciplinary research.

Example of a typical product

An example of a co-creation project is the development of the visualisation of student data collected across different learning management and adaptive learning technologies and summative assessments. Teachers asked for an approach to integrate the data in a meaningful way to support differentiation and personalization of learning for students. This project is a collaboration between 3 schools, an adaptive learning technology company, an assessment company and pedagogical and AI scientists. The iterative design approach ensures the connection between educational practice, science and business development.

Swiss EdTech Collider – Switzerland

Partners

EPFL University, Foundations, Governmental Entities, Corporate Partners, Schools (private/public), Educational Institutions, Teacher Training Centres (list on website, https://www.edtech-collider.ch/partners/).

Main goals

The aim is to create a marketplace for the EdTech start-up community and to enhance the visibility of EdTech companies by creating a unique ecosystem and network in and around education and EdTech that fosters encounters with potential partner organisations, customers, investors and research, as well as enables synergies among start-ups.

Size and duration

NPO Association, founded in 2017, 1 FTE, 90+ EdTech members (status on 1 January 2023).

Focus group:

- All levels of education: from K-12 to corporate learning and training to lifelong learning

Focus on:

- De-fragmenting the EdTech market
- Linking start-ups and labs
- Facilitating pilot tests in schools (testbed programme)
- Sharing challenges and difficulties (e.g., divergent data protection schemes)

Description of programme

While many accelerators aim to boost the development of start-ups in a short, limited period, the Swiss EdTech Collider is a membership-based, long-term effort to nurture the Swiss EdTech ecosystem by connecting the stakeholders: EdTech companies, customers and decision makers in private and public education system, chief learning officers, investors, researchers, governmental organisations, and other EdTech initiatives and hubs.

Main activities

The programme supports EdTech start-ups in all life-cycle stages – from early stage to well-established ones – by creating "collision" opportunities and matching them with potential customers, partners and investors; by facilitating the pilot testing of EdTech products in schools (Swiss National EdTech Testbed Program, https://www.edtech-collider.ch/testbed/); by enabling translational research in learning sciences by supporting master theses of university students in EdTech companies; by connecting start-ups with business SME's (Subject-matter experts) (e.g. legal, financial) based on their individual needs.

Outcomes

More than 130 start-ups have been involved since 2017, with some leaving or disappearing during that time. On average, about 12 new start-ups are joining the Swiss EdTech Collider every year as new members after a selective application process, leading currently to an average number between 90 – 100 member start-ups (on 1 January 2023). Some start-ups have merged, acquired each other or have been acquired by third parties. 10 master theses in learning sciences have been successfully conducted in start-ups since 2019. Also, the Swiss EdTech Collider has become a partner or member of various educational initiatives/systems (DIH EU, EPFL LEARN with the EPFL ML4ED Lab, EETN, EEA, BeLEARN) and has established itself as the EdTech reference in Switzerland.

Example of a typical product

Dynamilis (https://dynamilis.com/en/), a ML based app for improving handwriting: when children write on paper, the only way to assess their handwriting is the static shape of the produced letters. When writing on a tablet, one may also analyse the dynamics of the finger movements that generated the handwritten words. The analysis relies on these dynamic data: the speed of the pen, its pressure on the tablet as well as its angles with respect to the tablet surface (tilt). As these data points are collected 240 times per second, for several minutes, and data has been collected with more than 10 000 pupils, Dynamilis uses ML to parse these massive data sets. The algorithms extract properties of the hand movements that the human eye could not perceive, such as the second derivative of the pressure of the pen. The solution then uses dimensionality reduction methods to compute the position of every child's production in a 3D space. In this space, it can measure how far a particular child is from a child with satisfactory handwriting skills. This method takes into account the age, the gender as well as the laterality (left- vs right-handed) of the child. The results of the analysis methods lead to proposing games – developed in consultation with therapists – specific to the child personal weaknesses. Teachers, parents, professionals can then follow the progress of a child.

Tübingen Center for Digital Education (TüCeDE) – Germany

Partners

Tübingen has a rich ecosystem on digital education and artificial intelligence. Within the center, strategic university partners and networks of digital education (e.g., Hector Research Institute of Education Sciences and Psychology [HIB], LEAD Graduate School & Research Network, Tübingen School of Education [TüSE]), educational technologies (e.g., Intelligent Computer-Assisted Language Learning, Department of Computer Science, Cluster of Excellence Machine Learning for Science), and independent research institutes (e.g., Leibniz-Institut für Wissensmedien [IWM], German Institute for Adult Education [DIE]) are actively involved.

Main goals

We aim to strengthen the transfer expertise in digital education. The center is conceptualised as a research and transfer hub to support the participating research institutes to transfer their knowledge into practice, and to prepare teachers for teaching and learning with available and cutting-edge technologies.

Size and duration

More than 30 researchers from different fields such as educational research, psychology, computational linguistics, subject-matter didactics, digital humanities, computer science, and medicine are working together. The centre is based on an initial funding of 1.35 million (duration 5 years) from the Vector Foundation, and on the same amount of internal university funding. Additionally, TüCeDE has been successful in securing third-party funding for establishing federal competence centres (9.5 million) to advance the transfer strategy.

Focus group:

- primary, secondary and higher education

Focus on:

- knowledge transfer and development
- professionalisation of educational sector

Description of programme

TüCeDE has three working areas. In the area Transfer and Professional Development, transfer and professionalisation strategies are implemented. In the area technology-enhanced learning, evidence-based instructional concepts are developed to support students' subject-specific learning. In the area Innovative Technologies, cutting-edge technologies are developed and researched with the aim to scale meaningful learning environments (e.g., by using big data, artificial intelligence, intelligent tutoring systems, sensors, VR).

Main activities

TüCeDE focusses on transfer and research activities. We establish measures of transfer (e.g., a clearing house on digital education, implementation of professional development programmes), as well as support for research, in close cooperation with renowned local stakeholders such as LEAD, HIB, and IWM. A main emphasis in these activities lies in the co-design with educational practice (i.e., teachers, educational administrators).

Outcomes

Scalable prototypes for transfer and professionalisation, evidence regarding the effectiveness of educational technologies, and publications as outcomes of interdisciplinary research.

Example of a typical product

In the context of interdisciplinary research (e.g., via LEAD or TüSE), scalable prototypes have been developed and evaluated. Examples comprise intelligent tutoring systems, interfaces to assess students' attention, or subject-specific teaching units for adaptive teaching. These prototypes are used as good-practice examples, a crucial brick of our professional development programmes and transfer measures. Additionally, these transfer measures are enriched with meta-analytical evidence via our clearing house.

EDUCATE Ventures Research Ltd – the United Kingdom

Partners

Swedish EdTest, ISTE, The DXtera Institute, Unthinkable.

Main goals

To increase the effectiveness of evidence generation and application by members of the EdTech ecosystem, and to help them leverage data and AI. We do this in two ways firstly, by training EdTech SMEs, Investors and educators across K12, adult education and HE to develop and/or use evidence-informed products that benefit human learning; and secondly by providing consultancy to help organisations use AI and data science to understand human learning behaviours.

Size and duration

EDUCATE Ventures has been operating in the EdTech space for 5 years, and currently has fifteen team members, equivalent to 7 FTE staff members. EVR reported a revenue of GBP 500 000 for the most recently reported financial year.

Focus group:

- EdTech companies and Investors
- Educators and trainers
- Training and developoment departments
- Educational and training institutions/Businesses
- Learners

Focus on:

- Design of Evidence and Data structures, processes and readiness within organisations: theory of Change and Logic Modelling
- Articulation of organisational education/training needs
- Ethics of AI in education

- Knowledge transfer and development
- AI and data science

Description of programme

EVR provides two main services:

Modular training about data, evidence, and AI. We use our expertise in educational research to support, train and mentor the EdTech community in the development of research skills, ensuring products made for teaching and learning really do work.

Capacity building and bespoke consultancy to enable organisations to better leverage AI and data for educational benefit. We are the Artisans of AI: we use AI to identify, evidence and visualise the complex human learning behaviours that build human intelligence.

Main activities

The EDUCATE Accelerator Programme

We accelerate a research mindset in EdTech SME's, supporting them in to developing evidence-informed products to benefit human learning. Our training has been delivered in various forms to over 350 EdTech Companies and comprises of a series of workshops and dedicated mentoring sessions, supporting EdTech's to develop their Theory of Change and Logic Model, as well as to conduct a literature review and identify the relevant research methodology for measuring their educational outcomes. Our research team are all either PhD recipients or doctoral candidates, who specialise in various aspects of technology enhanced teaching and learning.

Consultancies

We help organisations gather and use data to understand human learning behaviour. Initially we work with clients to arrive at their idea of a "Golden Thread", a pedagogical imperative that underlies their desired goals. This is usually followed by a series of rapid evidence reviews, creation of an ontology, review of their data sources, and recommendations for becoming AI-ready. In some cases, this is demonstrated through and MVP dashboard.

Outcomes

Logic Models and Theories of Change developed by all graduates of the accelerator programme, operating as a strategic dashboard for the EdTech. A number of graduates have received an EdWard Level 1, having produced a rigorously reviewed Research Proposal. MVPs developed as part of the bespoke consultancies. Ontologies of abstract pedagogical concepts (such as metacognition, self-efficacy, etc.) and related research publications.

Example of a typical product

The EDUCATE Accelerator Programme (see above) 5 iterations of the programme saw graduates produce Logic Models. Our most financially successful Alumni include Busuu, Century Tech, MyTutor, Kano, Yoto and Pobble.

IMEC Smart Education – The Flemish Community of Belgium

Partners

The key partners are research groups from the research institutions KU Leuven, University of Ghent and Vrije Universiteit Brussel that are affiliated with IMEC, Flanders' research and innovation hub for nano-electronics and digital technologies.

Main goals

IMEC Smart Education is a strategic research and innovation programme that aims to develop state-of-the-art technologies in order to address grand challenges in education and training. Through co-creation with industry and schools, it also aims to incubate novel solutions and services, and accelerate their adoption in the market, as such contributing in a sustainable way to the digital transformation of education and training.

Size and duration

The programme started in 2017 and is set to continue until at least 2026. It employs approximately 40 researchers on an annual basis on a seed funding of EUR 1 million yearly, leveraging towards external funding.

Focus group:

The target group comprises learners and teachers from all levels of compulsory education and higher education as well as from corporate training and lifelong learning.

Focus on:

- strategic basic research
- co-creation of educational technologies, with a strong focus on AI
- articulation of needs with educational institutions
- business development
- knowledge transfer and development

Description of programme

The programme focuses on research on smart technologies (such as sensors, algorithms, and adaptive learning platforms) that are grounded in artificial intelligence and facilitate interaction and collaboration in the learning process, laying the foundation for tailor-made learning solutions. The development and evaluation of these technologies is driven by theories in the learning sciences. To realise its ambitions, the programme brings together IMEC researchers from a wide range of scientific disciplines and domains, such as instructional psychology & technology, statistics, machine learning and artificial intelligence, language technology, engineering sciences, neurosciences and social sciences. It has also forged a strategic alliance with the local industry through the creation of EdTech Station, the Belgian alliance of EdTech companies.

Main activities

Efficacy studies, research on new methodologies for computational data analysis, technology development, creation and maintenance of research infrastructure, co-creation of prototypes.

Outcomes

Scientific knowledge on learning effectiveness, new methods for data analysis, demonstrators, prototypes of new EdTech solutions.

Example of a typical product

Increasing product diversification in the manufacturing industry requires rapid up- and reskilling, necessitating flexible training solutions. The COSMO project (Cognitive Support in Manufacturing Operations) researched and developed data-driven techniques for creating content for assembly training applications in AR and VR, and for adapting training content to the skill level of the individual operator. The project demonstrated that work instructions for digital training platforms can be generated more efficiently by analysing recordings of expert operators through computer vision and natural language processing. It also showed that adaptive work instructions, tailoring the level of detail in work instructions to the skill level of the operator, reduced the mental effort of operators and sped up assembly times. The project involved two education technology companies, two manufacturing companies, five research groups and four secondary schools from vocational and special needs education. https://vimeo.com/624275559.

CIRCLS (Center for Integrative Research in Computer and Learning Sciences)[6] – the United States

Partners

The lead is Digital Promise, with partners at EDC, SRI International and the University of Pittsburgh. Digital Promise, EDC and SRI are non-profit organisations.

Main goals

CIRCLS is a hub that interconnects separately funded National Science Foundation research projects, each of which investigates emerging technology for teaching and learning. Recently, research and development topics related to AI are featured in the portfolio of projects.

Size and duration

CIRCLS has existed for approximately 10 years, although has previously operated under different names. The CIRCLS organisation itself is funded for USD 3 million, and will continue at least until January 2024. Approximately 50 separately funded research projects participate in CIRCLS, and individual projects have grants of between USD 100 000 and 1 million. The overall extent of CIRCLS is indicated by the size of its mailing list

Focus groups:

- CIRCLS builds a research community among computer scientists, learning scientists and others who are exploring how advanced technologies can help teachers and learners.
- CIRCLS intentional serves emerging scholars, seeking to involve them in this community.
- CIRCLS also engages educators in the work.

Focus on:

- Synthesising the work of individual research projects

- Envisioning next research questions and research projects
- Engaging the community in tackling issues at the community level, for example, how to conduct research in partnerships and how to advance equity

Description of programme

CIRCLS build and hosts a community that investigates emerging technologies for teaching and learning. These technologies can include AI, augmented and virtual reality, machine learning, learning analytics, simulations, visualizations, games, wearable technologies, robots, and accessibility technologies, among others. Learning sciences theories and approaches may include design-based research, computer supported collaborative learning, embodied cognition, analysis of discourse and argumentation, learning analytics, educational data mining and more. Throughout the community, there is a strong emphasis on equity in student learning.

Main activities

CIRCLS has four kinds of main activities: (1) To build the community, we reach out to those who receive awards, to educators, to emerging scholars and to others who could enrich our community; we also broker relationships among those in the community. (2) To enable collective work, we host participatory activities like working groups to define new research questions or approaches. We also host a major convening approximately every two years. (3) To map and synthesise the work, we analyse the portfolio or project also involve teams in writing community reports. (4) To disseminate insights, we produce a newsletter, publish a series of Rapid Community Reports, publish resources, and more. Two important special activities are our mentoring series for emerging scholars and CIRCLS Educators, a group of researchers and educational practitioners.

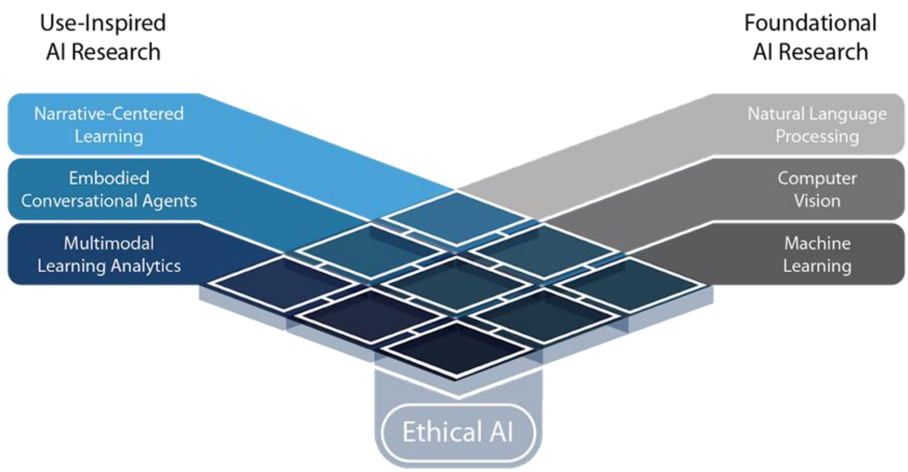
Outcomes

The main outcomes of CIRCLS activities are (a) enabling a shift from only individual research projects to working together across projects (b) involving a greater diversity of people in the work (c) understanding and disseminating what the work is accomplishing and (d) helping the community to envision and propose the next level of research questions and projects.

Example of a typical product

A characteristic “product” of CIRCLS is a synthesis of the insights and directions across a broad community. Our convenings are not typical “principal investigator meetings” but are instead interactive events with a purpose and an outcome. The most recent convening, CIRCLS’21, brought approximately 350 researchers and others together to determine how the emphasis of the work could evolve from “broadening” to “empowering” – a difference between simply reaching learners and giving them tools and approaches that power their future learning journeys. The structure of the convening followed a storyline leading up to a townhall in which teams shared insights for the future of this field. The insights were captured in a graphical report available here: https://circls.org/circls21report.

Annex Figure 13.A.1. Ethical AI



Engage AI Institute (full name is "The National Science Foundation AI Institute for Engaged Learning")[7] – the United States

Partners

The lead is North Carolina State University. Strategic partners are Digital Promise, a non-profit organisation, University of North Carolina, Vanderbilt University and Indiana University

Main goals

For thousands of years, story has been the primarily medium for human learning – but as universal education became important, pedagogical approaches used story less. People have become less engaged in learning and efforts to increase learning outcomes in the general population are stalling. The main goal of this institute is to deepen engagement and advance learning by creating a new class of narrative-centered learning environments in which students can collaboratively engage with customised plots, synthesised characters, and realistic forms of interaction.

Size and duration

Engage AI is one of four AI Institutes in education, each funded by the National Science Foundation for 5 years and USD 20 million. Approximately 30-40 researchers will be involved each year.

Focus groups:

- primary and secondary education
- education in museums and other informal institutes

Focus on:

- foundational research
- natural language processing
- computer vision
- machine learning

- Use-Inspired research
- narrative-centered learning
- embodied conversational agents
- multimodal learning analytics
- communications among researchers, educators and the public

Description of programme

To accomplish the goal of revitalizing story-based learning, the Engage AI Institute conducts research on narrative-centered learning technologies, embodied conversational agents, and multimodal learning analytics to create deeply engaging learning experiences. We aim for the AI-driven learning environments to be built on advances in natural language processing, computer vision, and machine learning. We are focused on creating AI-driven narrative-centered learning environments to support collaborative inquiry learning in both formal and informal learning settings. Advances in core AI technologies drive new levels of interactivity and multimodal engagement, as well as support the creation of powerful predictive models of student learning.

Main activities

The Institute will advance foundational AI techniques needed in education. It will investigate prototype narrative-centered learning environments. It will involve teachers, students and others in the work. It will advance ways to monitor and adapt learning via multiple types input, which could include visual input, audio input, and interactions with the technology. Ethics and Equity are core concerns and will interwoven in every project from start to end. The “Nexus” activity, led by Digital Promise, will create meaningful two-way engagement between the people in the Institute and people in industry, education, research and policy outside the Institute.

Outcomes

Prototype AI-enabled narrative learning environments will be developed and evaluated each year. Advances in Foundational AI will result in tools and techniques that will be shared. Advances in multimodal learning analytics will also be shared with the research community. Advances in approaches to integrating ethics and equity into the work will be dissiminated. The Nexus activity will share knowledge and invite participation with a broad public.

Example of a typical product

A typical product will be a game-like, immersive learning environment for K-12 students. Students may be asked to explore a phenomena or solve a problem by navigating a virtual space, such as an island, and talking with the people they encounter on the island. They will also discover and interact with resources that can help them in their quest. The AI elements will allow for an evolving, customised plot and for new characters whose appearance is synthesise and whose behaviors and speech are generated. The AI elements will allow the story to adapt to the participating students, with the aim to maximise both engagement and learning.

National Artificial Intelligence Institute in Adult Learning and Online Education (AI-ALOE)[8] – the United States

Partners

Strategic partners are academic (Georgia Institute of Technology, Georgia State U, Vanderbilt U, Harvard U, Technical College System of Georgia, U North Carolina Greensboro), non-profit (1EdTech), and corporations (Boeing, Wiley, IBM, Accenture)

Main goals

The primary objectives of AI-ALOE are 1) expanding access to quality jobs and improving workforce reskilling and upskilling by applying the affordances of AI to transform online education for adult learners; 2) advancing foundational AI, particularly in human-AI interaction including personalisation, machine teaching, mutual theory of mind, and data visualisation; and 3) developing ethical, inclusive, user-centred design-based research and responsible AI.

Size and duration

About 75 people work on AI-ALOE initiatives, including about 50 that receive direct support. AI-ALOE is funded by the US National Science Foundation for USD 20 million from 2021-2026.

Focus groups:

- Vocational/technical education
- Higher and continuing education
- Employee training
- informal adult learning for occupational skills

Focus on:

- Development of scalable AI-based assistants that enable both instructors and adult learners to personalise teaching to their needs
- Creating and improving feedback loops among instructors, learners, and AI-based agents
- AI-powered enhancement of online cognitive engagement, teacher presence, and social interaction
- Large language models and generative AI
- Participatory design and ethical development for inclusion of diverse learners
- Capacity building of skilled designers and researchers in AI and education

Description of programme

Current AI-ALOE technologies include:

1. Apprentice Tutors: An Intelligent Tutoring System Providing Personalized and Adaptive Support for Math Problem Solving and Skill Learning
2. Jill Watson: A Virtual Teaching Assistant That Empowers Teachers to Support and Engage All Students
3. SAMI (Social Agent Mediated Interactions): An AI Agent Connecting Learners and Building Community in Online Learning
4. SMART (Student Mental Model Analyzer for Research and Teaching): An AI-Powered System for Formative Assessment and Feedback
5. VERA (Virtual Experimental Research Assistant): A Virtual Laboratory Supporting Inquiry-Based Learning in Ecology

Over the next four years, AI-ALOE will expand its technological innovations to aid online adult learning across a range of contexts: academic, organisational, and informal/lifelong.

Main activities and outcomes

AI-ALOE identifies challenges and opportunities in online adult learning; creates foundational improvements in AI to improve learning outcomes at the episodic, course, programme and career levels; and studies the impact of those innovations across a range of learners, organisations, and contexts, with particular emphasis on aiding workforce access for marginalised groups.

Global Research Alliance for AI in Learning and Education (GRAILE) – the United States

Partners

University of South Australia, University of Texas Arlington, Arizona State University, Monash University, The University of Queensland, Texas A&M University, and Southern Methodist University.

Main goals

The main goal of GRAILE is to advance research on AI in education and to help education providers with the adoption of AI to support education systems. GRAILE influences and develops policy and senior leadership in areas where AI intersects with learning in K-12, higher education and corporate settings. GRAILE provides guidance and best practices on the development of a vision and implementation of AI in education.

Size and duration

GRAILE is a network organisation designed for organisations interested in how AI intersects with education systems. GRAILE members are part of a deeply connected network of AI-minded institutions, seeking to advance knowledge and leadership capability building to drive organisational change and support the digital transformation within their institutions.

Focus on:

- articulation of AI needs with education and corporate institutions
- capacity building and professional and leadership development
- developing and demonstrating AI-integrated infrastructure to support education systems, learning processes and outcomes
- facilitate organisational change and business development
- policy and best practice development for implementation of AI in education systems
- co-creation of research and innovation
- research translation, knowledge transfer and dissemination

Focus group:

- primary and secondary education
- vocational education
- higher education
- corporate

Description of programme

GRAILE's agenda is focused on two main areas of work. One is to advance research and innovation on AI in education systems to help develop and evaluate an education system where AI capability becomes an integrated part of its ecology. Here the focus is on making sense of AI, test and pilot AI infrastructure, tools and solutions to support education processes and outcomes. The second body of work is concentrated on research translation, capability and leadership development to help drive organisational change and policies to support digital transformation and adoption of AI.

Main activities

There is a need for research and knowledge translation which requires an information ecosystem that targets the knowledge needs of senior administration and practical translation of research into classroom settings. GRAILE provides their members with a platform where they can participate in research and pilot studies, short courses, webinars, debates, and conference events. Besides these large scale public events GRAILE offers tailor-made engagement programmes where member organisations can benefit from direct support and capability programmes suited to their needs.

Outcomes

GRAILE produces annual reports on the state of AI and its impact on education systems and organisational change. It offers regular podcasts on key emerging trends and developments on AI in education, Yearly leadership retreats with leading experts for GRAILE members, Short courses and webinars to engage in professional development. GRAILE publishes research outcomes in academic and popular journals.

Example of a typical product

An example of a GRAILE event is the yearly Empowering Learners for the Age of AI conference (ELAI). This is an open global online conference held over two days across all time zones with key events hosted by conference nodes within Australasia, Europe and America. With over 1 500 registrations this conference has been welcomed as a much-needed platform to support community building and sharing on how AI is transforming education systems. This year, December 2023, ELAI will apply a hybrid format combing in person and online participation, hosted by Arizona State University.

AI Playground – Australia (Collaborators: University of South Australia, meldCX and Intel)

Main goals

Our future society will be dominated by AI, advanced technology and automation, and our next generation citizens and workforce needs to be AI savvy to continue to make a difference. This future starts now, and we need an AI curriculum in our schools to help prepare students to learn to develop AI, learn to interact with non-human actors and learn to critically engage in ethical discussions to co-own their future and be inventive in society. In the AI playground students can, develop AI and through play experience the workings of AI and engage in ethical discussions about the impact of their algorithms and understand what it takes to develop AI.

Size and duration

The AI Playground offers a cloud-based learning environment for schools to help teachers offer AI learning experiences to their students.

Focus on:

The AI Playground provides a safe place to:

- develop critical and computational thinking skills, teamwork skills, and design thinking skills.
- learn to utilise and shape AI to solve complex problems.
- learn to critically and ethically evaluate AI.
- develop networked learning skills ready to operate in hybrid human-AI partnerships.
- develop fluid agency to operate in world co-populated with non-human actors.
- access lesson plans and curriculum resources for teachers
- access teacher capacity building and professional development resources

- access a teacher online network

Focus group:

- primary and secondary education
- vocational education
- teacher training

Description of programme

The AI Playground offers a social space for exploration, it’s safe, playful, and inspiring. Our mission is to create an AI playground where students can take ownership over AI, play with it and develop AI to follow their imagination. The AI Playground is a digital learning environment that helps educators to bring AI into the classroom. The AI Playground offers students a way to learn together with AI to solve complex problems that humans struggle to solve on their own. This is done by providing students with challenges. These challenges, i.e. lesson plans, encourage students to take ownership over AI, play with it and develop AI to follow their imagination.

Main activities

The AI Playground provides schools access to learning with AI in a game-based environment by focusing on a set of challenges. These challenges enable students to actively explore AI in the real world, understand how it works and even develop AI to solve complex problems. Further the AI Playground provides teaching materials and resources to help teachers implement these challenges in their classroom and provide guidance on how to effectively use the AI playground as a world of imagination with problems ready to be solved. The AI Playground also provides access to a growing online community of teachers where ideas and resources can be shared to collectively grow the implementation of AI playground in schools.

Outcomes

In the AI Playground the students will team with AI to collaboratively solve complex problems based on challenges. This way students will have hands-on experience of AI capability and develop skills to create and train AI to solve problems and learning tasks they are confronted with.

Example of a typical product

An example of a lesson plan in the AI Playground is the Mars rover challenge (Annex Figure 13.A.2). Here the students will work with AI to learn about Mars exploration. The students will work in groups and the first problem to solve is how to build a Mars rover, to learn about rover design and use of sensors to collect data about the Mars environment. The students will use Lego to physically build the rover in the classroom. A process that will be supported with AI based on computer vision within the AI Playground. The students can team up with AI to explore and identify the Lego pieces that are required for the Rover design. By putting Lego pieces on their desk, the AI will recognise them and provide feedback about the pieces it has identified (colour, size, name, etc.). By interacting with the AI Playground the students learn to filter through the Lego pieces and select all the bricks they need for the rover component they are currently working on. The picture below on the left illustrates this process. On the right side in this illustration the students see the camera output form the AI Playground. This is where computer vision is used in real time to identify Lego pieces. In the cards presented in the lower section of this illustration, the students receive feedback about the Lego pieces that have been picked up by the AI. This is the phase where students learn if these pieces are required for the component they are working on. They will also receive more detail about each of these bricks and how many of these pieces they need. On the left side of the same illustration the students can see a 3d model of the Rover component they are working on. The students can use this 3d model to zoom in/out and rotate the component they are trying to build. This is a complex problem to solve and the AI Playground can help the students in real time. Together with AI the students can locate where each brick needs to go. Each Lego brick (one or multiple pieces) that has been placed on the desk will be highlighted in the 3d model. This way the students can work together with AI to match the pieces and support the building process. Over time AI will learn from the students' design pathways and the order in which they are building their Rover, meaning that AI can start to make recommendations about what might be the next brick the students can use.

As soon as they have finished their rover component the students can present it to the AI Playground for a final inspection to see if this part has been successfully completed. Once the entire rover has been built and the sensors have been programme and tested the students can travel to Mars and drive their digital Lego Mars rover twin in a simulated Mars environment (see second illustration on the right). Now they can drive around and explore existing Mars rovers and learn about their sensors and capability. They can trace back for example what the Nasa Perseverance rover has been doing. Furthermore the students van use their sensors and start collecting Mars data for analysis by themselves. Once they have completed their Mars mission they can travel back to earth.

Annex Figure 13.A.2. Mars Rover challenge

Center for Learning and Living with AI (CELLA) – The Netherlands, Finland, Germany, the United States and Australia

Partners

Co-led by Sanna Järvelä from the University of Oulu (Finland) and Inge Molenaar from Radboud University (the Netherlands), the center's partners include Maria Bannert from the Technical University of Munich (Germany), Dragan Gašević from Monash University (Australia), and Roger Azevedo from the University of Central Florida (United States).

Main goals

CELLA is set up as a global collaborative research center focused on equipping young learners to learn, live, and work in the age of AI. The aim is to develop research-based AI-driven learning technologies that promote children's learning skills and ensure their well-being.

Size and duration

The center is supported by a grant of CHF 2 million (EUR 1.9 million) from the Jacobs Foundation for five years. The team consists of five Principal Investigators supervising five PhD students and two postdoctoral researchers coordinating the team and research activities.

Focus group:

- primary and secondary education

Focus on:

- articulation of needs with educational institutions
- co-creation of innovation
- knowledge transfer and development

Description of programme

Our center will bundle the knowledge and skills from the teams in different fields to design, validate, and implement new AI-driven learning technologies to support learners of different ages to improve their self-regulated learning (SRL), that is, how they go about learning. Moreover, we develop and test practices and inclusive design principles that boost the agency of learners to make informed instructional decisions about their learning while working with AI.

Main activities

CELLA's main activities are divided into four global research phases. In the first phase, all sites focus on detecting similar SRL processes in a secondary education context using the same AI-driven system. In the second phase, each site investigates these SRL processes in more open and diverse educational arrangments. Phase 3 involves designing and implementing personalised support for SRL, and phase 4 focuses on the long-term development and support of SRL. Research phases are based on collaboration among researchers, schools, and edtech companies.

Outcomes

The findings from the four research phases are disseminated through various channels, including research publications, public blogs, and conferences such as EARLI and its special interest groups (e.g., SIG27). Each PhD student writes their dissertation on their CELLA research work.

Example of a typical product

In the first study that is running, we measure self-regulated learning (SRL) action processes of 12-15-year-old students during essay writing using the trace data of a digital learning environment (N= 250). This is done in classroom settings by all five teams in the different countries at secondary education schools, and the experiment is integrated into existing lessons. The findings serve to validate an AI-driven system that detects SRL about how students go about learning.

Notes

[1] https://www.nesta.org.uk/project/future-work-and-skills/

[2] See https://www.ai4t.eu/.

[3] The examples are selected based on the personal network of the first author and connections thereof to give a good overview of the ecosystem around AI and education. This does not have the intend to be a comprehensive overview.

[4] See Annex 13.A for a full description.

[5] See https://ai.eitcommunity.eu/#page-top and https://primabord.eduscol.education.fr/IMG/pdf/p2ia_francais_mathematiques_cp_ce1_ce2_web.pdf.

[6] circls.org

[7] engageAI.org

[8] https://aialoe.org

14 Digital strategies: providing a common vision for the future

Hyunkyeong Yun, OECD

This chapter provides an overview of countries and jurisdictions' digital education strategies. Outlining the changes in countries' digital strategies since 2019, it highlights past and present policy emphasis. The integration and use of digital technology in education have emerged as national priorities in many countries. Countries adopted forward-looking goals such as integrating technology into teaching, leveraging data analytics for personalised learning, and enhancing student outcomes.

Introduction

Any willingness to harness the opportunities offered by digital education and to mitigate its risks starts with a digital education strategy. While such strategies are not enough in themselves, as they may or may not be followed by implementation (see (Dellagnelo, 2023[1])), they are critical to set a direction for educators to follow.

As of 2020, about half of the OECD countries had specific digital education strategies (van der Vlies, 2020[2]). These digital education policies were mostly part of broader national digital innovation strategies, aiming to equip the future generation with digital skills and tools to prepare for the fast-paced digital society. However, the outbreak of COVID-19 has uncovered the state of digitalisation and led to further efforts regarding digital education.

Through the publication of digital education strategies, countries acknowledge the importance of the digital transition in education, although they do it in different ways. During the pandemic, governments focused on allowing equitable and accessible remote learning, and either revised, strengthened, or created national digital education strategies (and policies).

This chapter presents countries' digital education strategies and their changes since 2019, possibly because of the COVID pandemic. After a brief overview of countries digital education strategies, this chapter focuses on what has been done to seize the momentum created by this shift towards digital education, and what may be in store moving forward. Countries' digital strategy headings and upcoming priorities are presented in tabular format in an Annex.

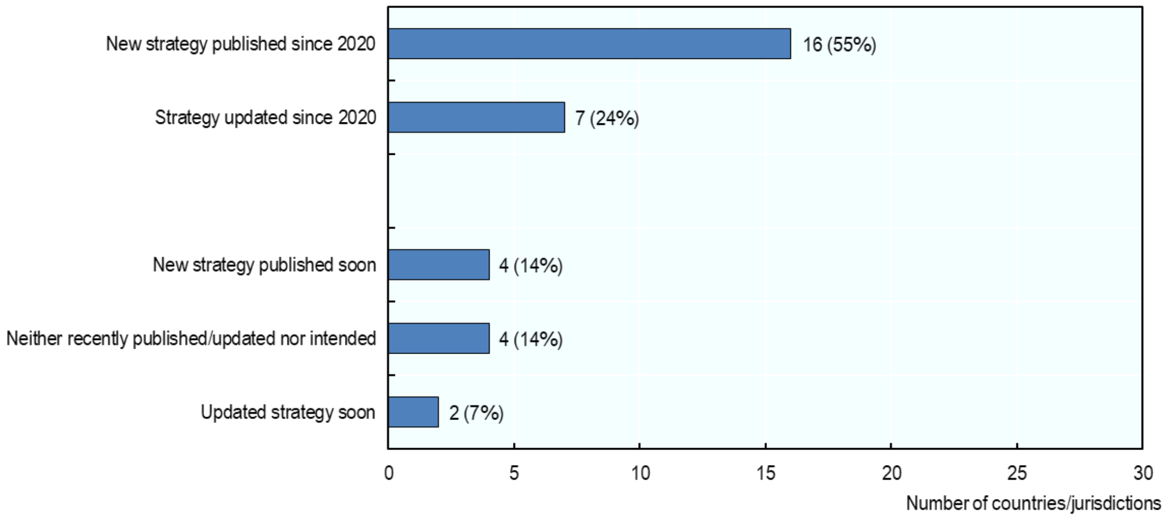
Updating or strengthening existing strategies

The OECD survey on digital infrastructure and governance asked which countries have a digital education strategy and whether it was recently updated or published. Figure 14.1 shows that most countries/jurisdictions have education strategies that focus on digital education. In particular, 24 countries/jurisdictions out of the 29 for which we have information have recently published new or updated digital education strategies or have one incoming. Specifically, 16 countries published new strategy since 2020, while 7 updated their existing strategy. A few have suggested new (4) or updated (2) digital education strategy in the next 6 months, while 4 have neither a recently new published or updated digital education strategy nor intentions.

Table 14.1 details the availability and timing of each country's digital education strategies. Most countries, apart from Brazil, Canada, Chile, Czechia, Iceland, and Sweden, have a published digital education strategy. Countries that already had strategies regarding digital education before 2020 have either modified their plans or implemented new policies.

Some countries have implemented broader, general education strategies that put strong emphasis on digitalisation in education. Hungary's Public Education Strategy 2021-2030 covers its education priorities for the next decade that centres on digitalising education. Similarly, Estonia's Education Strategy 2021-2035 sets long-term education goals that puts digital education at its core. Italy's COVID-19 mitigation measures, outlined in the 2021 National Recovery and Resilience Plan, covers digital education strategies as key pillars to its recovery from the pandemic and to prepare for the post-pandemic digitalised world.

Figure 14.1. Digital education strategies (2024)



StatLink https://stat.link/6lhgnb

Table 14.1. Availability and timing of countries' digital education strategies (2024)

	New strategy *published* since 2020	Strategy *updated* since 2020	New strategy will be *published soon*	Strategy will be *updated soon*	Neither recently published/updated nor intended	Name of the digital strategy document *published* or *updated* in the past five years
Austria		✓				8-Point Plan for Digital Learning
Brazil			✓			N/A
Canada					✓	N/A
Chile		✓				N/A
Czechia					✓	N/A
Denmark	✓					2021 Policy Agreement
Estonia	✓					Education strategy 2021–2035
Finland	✓		✓			Policies for the digitalisation of education and training (2023-2027)
France			✓			Digital Strategy for education 2023-2027 (*Stratégie du numérique pour l'éducation 2023-2027*)
Hungary	✓					Public Education Strategy 2021-2030
Iceland					✓	N/A
Ireland		✓				The Digital Strategy for Schools to 2027
Italy		✓	✓			National Recovery and Resilience Plan (PNRR) (updated strategy) / National Digital School Plan (intended strategy)
Japan	✓					Promoting measures to utilize cutting-edge technology to support learning in a new era 2019 Roadmap on the utilization of data education (2022)
Korea		✓		✓		Digital Transformation of Education (2023.2)

						Master Plan for ICT in Education (2019-2023)
Latvia	✓					National Development Plan 2021-2027 & Education Development Guidelines 2021-2027
Lithuania	✓					White paper on EdTech
Luxembourg	✓	✓				Einfach Digital
Mexico	✓					*Agenda Digital Educativa 2020*
Netherlands		✓				Digitization agenda: Primary and secondary education
New Zealand	✓					Connected Ako: Digital and Data for Learning
Slovenia	✓					Digital Education Action Plan
Spain	✓					Plan de Digitalización y Competencias Digitales del Sisitema Educativo
Sweden					✓	N/A
Türkiye	✓					Turkey's Education Vision 2023
United States	✓					2024 US National Education Technology Plan
England (United Kingdom)	✓					DfE Digital, Data and Technology
Flemish Comm. (Belgium)	✓					Digital Jump (Digisprong)
French Comm. (Belgium)				✓		Digital Strategy for Education (*Stratégie Numérique pour l'Education*)
Total	**16**	**7**	**4**	**2**	**4**	

Note: The digital education strategies referred to are specific digital education policies officially published within the past five years. Digital education policies refer to the application of digital technologies and innovative technologies to benefit education. Countries marked without digital educations strategy may have a broader national or jurisdictional digitalisation plan or strategy that includes education in some respect.

StatLink https://stat.link/n3702o

Digital strategies responding to the COVID-19 crisis.

Many countries updated existing strategies or designed new strategies during the COVID-19.

The Flemish community of Belgium is a notable example of a comprehensive response to the pandemic that was leveraged into more permanent policy. The government launched *Digisprong* (Digital Jump), a digital education strategy developed during the crisis under the *Vlaamse Resillience* (Flemish Recovery) plan, a national initiative to address issues raised by the COVID-19 pandemic. With the funds from the Recovery and Resilience Facility (RRF) of the European Commission, *Digisprong* aims to build a secure ICT infrastructure, equip digital devices to students on a one-to-one basis, provide training in digital competences to educators, establish relevant ICT school policies such as the prevention of cyber-bulling and the improvement of digital inclusion, and build a *Digisprong Kenniscentrum* (Knowledge Centre) to foster dialogues between schools and related stakeholders. Thanks to the policy a key milestone of providing digital devices to all students was reached.[1]

Some other countries adapted existing plans to face the challenges posed by the health crisis. Austria launched the 8-Point Plan for Digital Learning (*8-Punkte-Plan für den digitalen Unterricht*) in 2020 as part of the Digital Austria Act, a pre-existing national digitalisation strategy that was updated following the transition to digital learning due to the COVID-19 pandemic. One focus of Digital Austria is crisis resilience: considering the lessons learned during the pandemic, it promotes digitalisation as a means for a sustainable and resilient economy. In particular, the plan supports the improvement of the digital infrastructure within and outside schools, the development of digital learning materials and platforms and the provision of digital devices for students, with the aim of increasing their digital competence. It aims to sustain a continuous interest in building a stronger digital learning environment for the future.[2]

Some countries that had no digital education strategy prior to the pandemic have developed one or included a digital focus in their overall education strategy. In countries such as Czechia, Mexico and Brazil, digitalisation has become a high priority of their national education policy agenda. Czechia's national education strategy, Strategy 2030+, refers to digitalisation as a key feature in modernising its education system. Similarly, Mexico introduced the *Agenda Digital Educativa* for the 2020-2024 period, focusing on the provision of connectivity and digital equipment and on increasing access to digital physical infrastructure in rural regions. While different layers of policies on digital education were already in place, Brazil's National Digital Education Plan (PNED) aligns with the country's broader 2022-26 digital transformation strategy, a strategy mandated by the national Audit Court.

Other countries focused on the implementation of existing strategies, often accelerating their executions.

For some education systems, the pandemic accelerated the implementation of existing strategies. For instance, the French community of Belgium released a digital education strategy in 2018 that aimed to develop digital learning materials, train staff and students, equip schools with ICT infrastructure and develop digital governance to reform primary and secondary education. The COVID-19 crisis accelerated the execution of the 2018 digital education strategy, with various support from supplementary policies such as further funds allocated to improve broadband connectivity in school and supply digital tools to educational institutions and students with special needs. In its 2019-2024 Policy Declaration, the Wallonia-Brussels Federation put digitalisation as one of its priorities, consequently supporting the implementation of the 2018 Digital Education Strategy across different policy sectors and government levels.[3]

Finland adopted in 2015 the Digital Leap Programme aiming to modernise the ICT infrastructure in school, increase teachers' and students' digital competency, and facilitate the use of digital support for students with special education needs. Nonetheless, in comparison to other Scandinavian countries, schools in Finland used relatively fewer digital resources in teaching and learning.[4] During the pandemic, the government invested significantly on providing hardware ICT infrastructure to schools and digital devices to students and teachers, beyond the efforts under the Digital Leap programme. Improving access to and quality of ICT infrastructure remains the Finnish government's priorities in education for the future. The establishment of the Digital and Population Data Services Agency in 2020 illustrates the government's renewed commitment to monitor the uptake of digitalisation. In April 2023, the Ministry of Education and Culture published the Policies for the digitalisation of education and training until 2027. Under the recent strategy, Finland visions to achieve sustainable digitalisation in teaching, education, and training by 2027, putting emphasis on ensuring equal opportunities for everyone to learn with an effective use of digital tools.

Italy has introduced digital solutions into its education system from the mid-2000s (Avvisati et al., 2013[3]).[5] The 2015 National Digital School Plan aimed to enhance ICT connectivity, pedagogies, and digital skills for students and teachersThe Digital Plan has significantly enhanced the technological infrastructure in Italian schools. By 2020, 93% of classrooms had access to the Internet, and the student-to-device ratio improved from 1:8 in 2013 to 1:4. In addition, the Digital Plan has established over 14 000 "innovative learning spaces", such as tech-enhanced classrooms, digital hubs, and mobile labs. The pandemic spurred additional investments: funds were allocated for procurement of digital tools for students, and the 2021 National Recovery and Resilience Plan, backed by the Recovery and Resilience Facility (RRF) of the European Commission resources, invested in e-learning platforms, digital devices, and improved connectivity, earmarking an extra EUR 2 billion for 100 000 advanced classrooms by 2025. The subsequent "Digital School 2022-2026" strategy as part of the Recovery and Resilience Plan will streamline digital services, migrate to cloud platforms, implement a unified digital access platform, and promote single sign-on systems for government services.

But not all countries have digital education strategies.

Nevertheless, not all countries have a digital education strategy. Chile, Estonia, or Iceland do not have specific educational digital strategies, even though their governments consider digitalisation as key priority policy area. Chile has a national digital strategy that aims to drive a digital transformation of the country, including education. Estonia's Education Strategy 2021-2035 and Digital Agenda 2030 communicate the government's objectives to develop citizens' digital competences and digital literacy through education. Iceland has been undergoing digital transformation for decades under the agency, Digital Iceland. However, digitalisation in education is not a government's explicit priority.

Provincial and territorial governments in Canada oversee education, leading to no national digital strategy. Instead, regions have their own approaches. For example, Quebec introduced a Digital Action Plan for Education in 2018 to boost digital literacy and promote tech in education. Provinces and territories collaborate to exchange best practices regarding digital strategies, facilitated by the Council of Ministers of Education, Canada (CMEC).

Some frequent objectives of countries' strategies

Whether they were updated, initiated, or strengthened as a response of the COVID-19 crisis or not, most strategies a common focus on physical infrastructure (devices and connectivity) and on digital competences (of students and teachers). There are few more focuses on emerging applications of technology, with many upcoming strategies that will deal with AI and generative AI. More rarely do countries/jurisdictions try to make their digital ecosystem more user-friendly and more effective.

Addressing the Digital Divide

Chief among the issues brought about by COVID-19 was the digital divide coming from the difference in access to online learning between more and less socio-economically advantaged groups. Our data collection shows that many countries have a focus on improving their ICT infrastructure and availability of digital devices to bridge the socio-economic-related digital divide identified during theCOVID-19 pandemic. Table 14.2 shows the changes in expenditure in digital hardware infrastructure in the past five years (2018-2023).

Generally, most countries showed interest in providing access to digital devices and improving internet connectivity. Twenty-three countries out of 29 have focused on providing devices in school, and 21 countries focused on Wi-Fi or Mobile connection and/or on improving their broadband connection. Twenty countries increased their spending to provide devices for students and/or on students with special needs. Improving Internet servers was less popular, with 9 countries increasing their spending on their Internet servers and platforms.

Table 14.2. Significant changes to digital education policy and/or expenditure in the past five years (2024)

	Changes to digital education policy or expenditures in the past five years						
	Broadband connection	Wi-Fi or Mobile connection	Devices in schools	Devices for students	Devices for students with special needs	Internet servers	Other
Austria	✓	✓	✓	✓	✓		
Brazil	✓	✓	✓	✓	✓	✓	✓
Canada	✓		✓	✓	✓		
Chile	✓	✓	✓	✓	✓	✓	
Czechia	✓		✓	✓	✓		
Denmark							
Estonia		✓	✓			✓	
Finland	✓	✓	✓	✓	✓		
France	✓	✓	✓	✓	✓	✓	
Hungary	✓	✓	✓	✓			✓
Iceland							
Ireland							
Italy	✓	✓	✓	✓	✓	✓	
Japan		✓	✓	✓	✓		
Korea	✓	✓	✓	✓			
Latvia	✓	✓	✓	✓	✓		
Lithuania		✓	✓		✓		
Luxembourg	✓	✓	✓	✓	✓	✓	✓
Mexico							
Netherlands	✓	✓					
New Zealand	✓	✓	✓	✓	✓		✓
Slovenia	✓	✓	✓	✓	✓	✓	
Spain	✓	✓	✓	✓	✓	✓	
Sweden							✓
Türkiye	✓	✓	✓		✓		✓
United States	✓	✓	✓	✓	✓	✓	✓

England (United Kingdom)	✓	✓	✓	✓	✓		
Flemish Comm. (Belgium)	✓	✓	✓	✓	✓		✓
French Comm. (Belgium)	✓		✓	✓	✓		
Total (29)	**21**	**21**	**23**	**20**	**20**	**9**	**8**

StatLink https://stat.link/x0ys5i

Countries mostly prioritise provision of digital devices in institutions for students' use.

Several countries have leveraged post-pandemic recovery funds to provide digital devices to institutions and to students. For example, Latvia has started its "Computer for Every Child" project in 2021, which aims to provide every student and teacher with a computer and a computer library in schools by 2025.[6] Moreover, the Latvian government purchased 26 000 laptops for students in lower secondary education out of around 60 000 students enrolled in lower secondary schools in 2021, amounting to one third of the total enrolled students having a government-provided digital device.[7] In 2022, further funds from REACT-EU (Recovery Assistance for Cohesion and the Territories of Europe) and European Recovery Fund also financed the purchase of portable devices for students in need.

Austria has also implemented such a measure as part of its national recovery plan, with European Union budget funds from the European Recovery and Resilience Facility. Since the 2021-22 school year, 320 000 lower secondary school pupils have been equipped with digital devices. By the 2023/24 school year, 98% of secondary school pupils will be learning and working with digital devices. More than 40 000 teachers have received digital devices from the federal government and, in some cases, the federal states as educational tools.

In the Netherlands, the Ministry of Education, Culture and Science updated its previous digital education strategy, Digitalisation Agenda for Primary and Secondary Education 2019, with its new Dutch Digitalisation Strategy 2021. Under the new strategy, the government purchased 75 000 devices to provide students to enable their participation in remote learning, investing EUR 24 million.

In New Zealand, in order to implement a new digital curriculum designed in 2018, the country has invested more than NZD 700 million (EUR 380 million) to improve public schools and kuras' digital hardware infrastructure.

Countries also focused on improving Internet connectivity.

Some countries have adopted post-COVID policies on Internet connectivity that focus more on providing equitable digital learning environment at home by improving Internet availability. For instance, during the COVID-19 outbreak, Korea has collaborated with private telecommunication companies and service providers such as Samsung and LG to rent 316 000 digital devices to provide socially disadvantaged students with free digital devices and free data plans to ensure equitable Internet connectivity.

During the pandemic, Japan's Ministry of Education, Culture, Sports, Science and Technology (MEXT) took significant measures to advance digital education by revising their policies and increasing spending. They focused on amplifying Wi-Fi and cellular coverage in all educational institutions and ensuring broadband connectivity in vocational schools. A MEXT study revealed that the adoption rate of Wi-Fi in schools dramatically jumped from 48.9% in 2020 to 94.8% in 2022.

In 2023, France introduced its 2023-2027 digital education strategy, drawing insights from the COVID-19 experience and past consultations. Aligned with the France 2030 investment plan of EUR 54 billion, succeeding the "France Relance" pandemic plan, significant funds target digital infrastructure. Local authorities, under France 2030, have substantially invested in school connectivity (broadband, Wi-Fi, mobile connection, and Internet servers in schools) and provided students with tech devices for school and home use.

Future digital hardware priorities focus more on improving Internet connectivity.

Table 14.3 displays countries' future priorities in digital hardware infrastructure in the next five years. Internet connectivity in institutions such as schools is what countries prioritise the most, with 22 countries putting Internet access in institutions as future priorities and 19 countries having improving Internet speed in institutions as their priorities. Provision of digital devices in institutions and at home have become lower in importance for countries, with 12 countries prioritising the provision of devices for students in institutions and at home and 13 countries providing devices for student use in institutions.

Table 14.3. Digital education strategies priorities in hardware (2024)

	Policy: priorities in hardware									
	Devices for students in schools	Devices for students in schools and at home	Devices for teachers	Specific digital teaching equipment (e.g. interactive whiteboards, simulation tools)	Internet access in schools	Internet access everywhere (e.g. satellite Internet)	Internet speed in schools	Internet speed at home	Free mobile data roaming to access public education platforms	Other priorities
Austria		✓	✓		✓		✓			
Brazil	✓		✓	✓	✓		✓		✓	
Canada					✓	✓	✓			
Chile	✓				✓		✓			
Czechia	✓			✓	✓					
Denmark										
Estonia	✓		✓	✓	✓		✓			
Finland		✓	✓							
France										
Hungary		✓	✓	✓	✓		✓			
Iceland										
Ireland		✓	✓	✓	✓		✓	✓		
Italy										
Japan		✓								
Korea	✓*	✓*	✓*		✓*		✓*			
Latvia		✓	✓		✓	✓	✓			
Lithuania	✓	✓	✓	✓	✓		✓			
Luxembourg										
Mexico						✓	✓		✓	
Netherlands										
New Zealand			✓		✓	✓	✓	✓	✓	
Slovenia	✓	✓	✓	✓	✓		✓	✓	✓	✓
Spain	✓	✓*		✓	✓		✓	✓	✓*	
Sweden										
Türkiye				✓	✓					
United States					✓	✓				

England (United Kingdom)					✓		✓			
Flemish comm. (Belgium)	✓		✓	✓	✓		✓			
French comm. (Belgium)	✓	✓	✓	✓	✓		✓			
Total (29)	**13**	**12**	**15**	**13**	**22**	**5**	**19**	**5**	**5**	**1**

Note: A star (*) indicates that this provision is a priority at subnational levels of government, e.g. states, regions, municipalities. N=29.

StatLink https://stat.link/6vf3ez

For instance, as part of its Connected Education Innovation Programme (*Programa de Inovação Educação Conectada*), Brazil aims to support schools by providing universal access to high-speed Internet by 2024 and connecting remote regions in the Amazon.[8] Similarly, in Japan, MEXT aims to further invest in the technological framework of schools by enhancing broadband and Wi-Fi connectivity in the coming years. One of two pillars of Ireland's 2020 to 2027 Digital Strategy for Schools is the continuous investment in digital infrastructure especially on internet connectivity, which aligns with the government's goal of improving connectivity in remote schools, with added financial support for schools in underprivileged areas to boost their ICT capabilities.

Towards a digital transformation

While improving Internet connectivity and providing digital devices to schools and students either responded to the pandemic situation or to the witnessing of inadequate digital equipment, many countries' digital strategies also point to the need to provide more possibilities for digital tools and resources to be part of teaching and learning processes (and of school administrative processes).

Most countries prioritise developing digital learning and teaching resources.

Table 14.4 shows countries' digital education strategies in software in the next five years from our data collection. Most countries, 25 out of 29 countries, prioritise developing online educational platforms and digital learning and teaching resources. Next, 17 countries shown interest in improving or developing data and/or information systems, such as student information systems or education management information systems.

Around half of the countries from the data collection plan to provide and support in priority for learning management systems and different functions that support students' admission and exam administration. 12 countries plan to prioritise support learning management systems, 11 countries for digital exam administration and 11 countries for student admission management system.

In contrast, integrating innovative digital learning and teaching tools and personalising education using classroom analytics and intelligent tutoring systems were not most countries' priority area, having the least number of countries (7 countries) prioritising development of software for classroom analytics, followed by 8 countries for the development of intelligent tutoring systems.

Table 14.4. Digital education strategies priorities in software (2024)

	Policy: priorities in software								
	Online educational platforms and digital resources for teachers and student	Intelligent Tutoring Systems	Classroom analytics	Learning Management System (LMS)	*Data/ Information Systems (EMIS/ SIS)*	Digital credential system	Digital exam administration	Student admission management system	Other
Austria	✓			✓		✓	✓	✓	
Brazil					✓				✓
Canada	✓						✓		
Chile	✓		✓	✓	✓			✓	
Czechia	✓							✓	✓
Denmark									
Estonia	✓		✓		✓	✓	✓		
Finland	✓		✓		✓		✓		
France	✓		✓						
Hungary	✓			✓	✓			✓	
Iceland	✓		✓					✓	
Ireland	✓	✓				✓	✓		
Italy	✓				✓				
Japan	✓			✓	✓				
Korea	✓	✓	✓	✓	✓	✓		✓	
Latvia	✓	✓		✓	✓	✓	✓	✓	✓
Lithuania	✓			✓	✓		✓	✓	
Luxembourg	✓	✓				✓			
Mexico	✓	✓			✓	✓		✓	
Netherlands									
New Zealand	✓			✓	✓				
Slovenia	✓	✓	✓	✓	✓	✓	✓	✓	✓
Spain	✓	✓		✓	✓			✓	
Sweden							✓		
Türkiye	✓	✓		✓					
United States	✓								✓
England (United Kingdom)	✓				✓				
Flemish Comm. (Belgium)	✓				✓		✓		
French Comm. (Belgium)	✓			✓	✓		✓		✓
Total	**25**	**8**	**7**	**12**	**17**	**8**	**11**	**11**	**6**

Note: N=29.

StatLink https://stat.link/n3dpk4

Türkiye set its digital education priority as to enhance features within its digital learning resource platform, Education Information Network (EBA), as part of its Safe Schooling and Distance Education Project (SSDE). The ministry anticipates developing online learning and teaching resources through the EBA and expanding its functionalities to be further utilised in schools and at homes.

Similarly, Hungary aims to develop digital learning and teaching resources and content, along with the development of its public learning management system for education. Hungary's Educational Authority is responsible for providing in-service teacher trainings for active teachers and developing digital learning and teaching resources and content.

Some countries attempt to introduce AI technology in classrooms.

Korea is a point in case for an AI focus. Its recent digital education strategy published in 2023, the Digital Transformation of Education Initiative, focuses on realising "Education for All" via personalised learning for every student using cutting-edge technology such as artificial intelligence. As a main project of the initiative, the government is planning to introduce AI Digital Textbooks from 2025 on, whereby teachers and AI technology cooperate to develop customised lessons for individual students. Coding classes will also become part of compulsory education for primary and lower secondary education students by 2025. Selected AI pilot school projects called for by the strategy are already started. Since 2023, 300 Digital Leadership Schools have been in operation.

In November 2023, Austria introduced a comprehensive six-point package for schools aimed at integrating and managing AI, with the objective of preparing students for a self-determined and responsible life in a world shaped by AI. The plan involves establishing 100 AI pilot schools, emphasising AI in educational materials, textbooks, and teacher training. Support will be provided to schools and educators in utilising AI for written assignments, including schoolwork and final exams.[9]

Latvia's Digital Transformation Guidelines 2021-2027 seeks to use simulations and virtual labs, AI-based teaching and learning, and aims to leverage data analytics to personalise learning and enhance learning outcomes. State examinations will be digitalised, and digital tools such as early warning systems will be developed and utilised.

Ireland's 2020-2027 Digital Strategy for Schools reflects on the lessons learned from the pandemic and covers a wide range of topics from the use of AI in education through to developing competitive digital skills such as coding and computational thinking. For instance, the Draft Primary Curriculum Framework (2020) mentions "being a digital learner" as one of its seven main competence areas and calls for integrating the use of digital technologies across all subjects for students between first and sixth grade. In the recently published Primary Curriculum Framework for Primary and Special Schools (2023), STEM education became one of five core subjects, the integration of mathematics, science and other technology-related subjects aiming to foster students' digital skills.[10]

Other countries also put emphasis on establishing a safe, secured, and ethical online environment.

Some systems' strategies highlight the importance of creating the conditions for digitalisation. Denmark's 2021 Policy Agreement replaces its previous digital education strategy (Action Plan for Technology in Education). This policy agreement puts emphasis on ensuring safety and security in the online educational space and on creating a healthy digital culture. Among other objectives, England puts a strong focus on maintaining a secure and safe digital environment in the prevention of possible data breaches or system malfunction, and thus stresses the importance of cyber-security and online safety.

Conclusion

The COVID-19 experience has led many education systems to review their digital policies. While initial responses focused on providing adequate ICT infrastructure and digital tools to access online learning, many strategies also suggest a shift towards modernising and digitalising their education systems. Moreover, countries have strengthened their willingness to foster the digital competences of future generations to prepare them for the modern global economy. Digital education, in terms of fostering digital skills and strengthening the digital education infrastructure, has become a national education priority in many countries, making digitalisation in education a key rather than a supplemental element to national digitalisation strategies, as tended to be the case before the COVID-19 crisis.

While countries' digital education strategies aim, broadly speaking, to equip students with digital skills and bridge the digital divide, some adopt forward-looking goals: integrating more consistently digital technologies to teaching and learning and school management systems, actively utilising data analytics to enhance student learning outcomes and assist teachers to create effective and personalised learning systems and ensuring a safe, secure, and ethical digital environment.

Having a digital education strategy, ideally designed in discussion with all education stakeholders, is key. While many existing strategies could be expanded to make countries digital education ecosystem more user-friendly, effective, and benefit from the affordances of available technology, having a strategy provides a direction of travel to all stakeholders within an education system. This is just a first step though. Implementing one's strategy is the next (and a more difficult) challenge.

References

Avvisati, F.; S. Hennessy; R.B. Kozma and S. Vincent-Lancrin (2013), "Review of the Italian Strategy for Digital Schools", *OECD Education Working Papers*, No. 90, OECD Publishing, Paris, https://doi.org/10.1787/5k487ntdbr44-en. [3]

Dellagnelo, L. (2023), "The role of support organisations in implementing digital education policies", in *OECD Digital Education Outlook 2023. Towards an Effective Digital Education Ecosystem*, OECD Publishing, https://doi.org/10.1787/c74f03de-en. [1]

OECD (2023), *Country Digital Education Ecosystems and Governance. A companion to Digital Education Outlook 2023*, OECD Publishing, https://doi.org/10.1787/906134d4-en. [4]

van der Vlies, R. (2020), "Digital strategies in education across OECD countries: Exploring education policies on digital technologies", *OECD Education Working Papers*, No. 226, OECD Publishing, Paris, https://doi.org/10.1787/33dd4c26-en. [2]

Annex 14.A. Main Headings and Objectives of Country Digital Strategies

Annex Table 14.A.1. Digital education strategies and their objectives

Country	Digital Education Strategy	Objectives
Austria	8-Point Plan for Digital Learning Digitale Schule (bmbwf.gv.at)	8-Point Plan: 1. Digital School portal 2. Standardisation of the platforms 3. Continuing education for educators 4. Aligning Eduthek with curricula 5. Quality mark for learning apps 6. Expanding the basic IT infrastructure at schools 7. Digital terminals for students 8. Digital terminals for teachers
Brazil	N/A	
Canada	N/A	
Chile	N/A	
Czechia	National Strategy for the education policy of the Czech Republic up to 2030+ brozura_S2030_en_fin_online.pdf (msmt.cz)	Objective 1: Acquisition of competences Objective 2: Reduce inequality in access to quality education. 1. Transforming the content, methods, and assessment of education 2. Equal access to education 3. Support for teacher staff 4. Increasing personal capacity, trust, and cooperation 5. Increasing funding and ensuring its stability[11]
Denmark	2021 Policy Agreement Aftaletekst om styrket digital dannelse af børn og unge (uvm.dk)	1. Raising students' awareness about safety and security issues on the Internet 2. Developing digital teaching resources 3. Fostering a healthy digital culture in schools.
Estonia	Education strategy 2021–2035 Strategic planning for 2021–2035 | Haridus- ja Teadusministeerium (hm.ee)	1. Digital inclusion of diverse and accessible learning opportunities at different levels and types of education 2. Digital literacy of educators, who are expected to be knowledgeable about the trends and methodologies related to new digital technologies and apply them in thoughtful and purposeful ways 3. To provide equal opportunities stimulating digital content development skills and digital literacy skills across citizens of all age groups to increase competitiveness of all learners
Finland	Policies for the digitalisation of education and training (2023-2027)(valtioneuvosto.fi) Framework for Digitalisation in Early Childhood Education and Care, Comprehensive School Education and Liberal Adult Education in 2023 Framework for the digitalisation of early childhood education and care, pre-primary and basic education and liberal adult education - OKM - Ministry of Education and Culture, Finland	**Policies for the digitalisation of education and training until 2027** Vision: 1. Everyone's ability to learn and develop their competence is improved through digitalisation 2. Digital solutions constitute a high-quality, interoperable digital operating environment supporting cooperation between actors. 3. Digitalisation supports knowledge-based development **Framework for Digitalisation in Early Childhood Education and Care, Comprehensive School Education and Liberal Adult Education in 2023** - Further develop the overall steering of digitalisation at different levels of government.

Country	Digital Education Strategy	Objectives
		- Develop the knowledge base and information management of the industry. - Enable a better foundation of knowledge management. - Promote the quality and equal implementation of the digital operating environment of education and teaching and its application. - Support the use of pedagogically high-quality digital learning products in education and teaching - Enable equal implementation of learning in the digital operating environment and strengthen digital competence comprehensively. - Promote the development of higher quality services in the sector. - Develop financing models for digitalisation in the sector and their impact. - To provide better visibility to different levels of enterprise architecture, up-to-date information, and a coordinated feedback channel for operators in the field. - To enable a more efficient data infrastructure for research in early childhood education and care, pre-primary and basic education, and liberal adult education to support high-quality scientific research, practical work, decision-making and planning.
France	Digital Strategy for education 2023-2027 (Stratégie du numérique pour l'éducation 2023-2027)	1. An engaged ecosystem serving a shared public policy 2. A digital education that fosters citizenship and digital skills 3. An educational community supported by a thoughtful, sustainable, and inclusive digital offering 4. A new state of play for a user-oriented ministry's information system.
Hungary	Public Education Strategy 2021-2030 Köznevelési stratégia.pdf (kormany.hu)	1.Ensuring the Internal Balance of Education 2. Development of Human Resources Participating in Public Education as a State Public Service 3.Fair, Individualized Consideration of Public Education 4. Responding to the Challenges of the 21st Century in Public Education • Developing digital competences and services • Enhancing foreign language proficiency • Content development • Modernizing public education infrastructure 5.Development of Education for Hungarian Communities Abroad – Supporting the Education of National Minorities in Hungary
Iceland	N/A	
Ireland	The Digital Strategy for Schools to 2027 221285_6fc98405-d345-41a3-a770-c97e1a4479d3 (1).pdf	1. "Supporting the embedding of digital technologies in teaching, learning, and assessment." 2. "Digital Technology Infrastructure" - Supporting the goal of leveraging digital solutions at school via maintaining investment in digital technology infrastructure 3. "Looking to the future: policy, research and digital leadership"
Italy	PNRR (updated strategy) / National Digital School Plan (intended strategy)	PNRR objectives: 'Digitalisation, innovation, competitiveness, culture and tourism Green revolution and ecological transition
Japan	Promoting measures to utilize cutting-edge technology to support learning in a new era https://www.mext.go.jp/component/a_menu/other/detail/__icsFiles/afieldfile/2019/06/24/1418387_01.pdfhttps://www.mext.go.jp/component/a_menu/other/detail/__icsFiles/afieldfile/2019/06/24/1418387_01.pdf Roadmap on the utilisation of education (2022) Roadmap on the Utilization of Data in	*Promoting measures to utilize cutting-edge technology to support learning in a new era.* Objective: 1.Effective Utilisation of Advanced Technologies Based on ICT, Including Distance Education, and Effective Utilisation of Education Big Data. 2.Establishment of the Fundamental ICT Infrastructure. • Opening up SINET for Primary and Secondary Education. • Actively Promoting the Use of Cloud Services. • Presenting Concrete Models for Cost-Effective Infrastructure Development. • Promoting Initiatives to Foster and Secure Personnel

Country	Digital Education Strategy	Objectives
	Education (digital.go.jp)	with Specialized Expertise and Achieve Stakeholder Awareness. *Roadmap on the utilisation of education (2022)* 1. Big picture of data in education 2. Putting surveys, etc. online, and standardising data in education 3. The way the platform in the field of education ought to be 4. Enhancing data utilitsation environment for schools, local municipalities, etc. 5. Rule/policy for the utilisation of data in education 6. Ensuring lifelong learning environment 7. Realising support to students in need through data connection 8. The way of education itself in anticipation of the digital society ought to be
Korea	Digital-based Education Innovation Plan [카드뉴스] 모두를 위한 맞춤 교육! 디지털 기반 교육혁신 방안 발표 (moe.go.kr)	1.Providing personalized learning opportunities tailored to each student's abilities and learning pace to nurture each student as a valuable individual. 2.Innovating teaching and learning methods using advanced technologies such as artificial intelligence in line with the digital transformation, aiming to achieve "Education for All" via personalized learning for every student." • Introduction of artificial intelligence digital textbooks for mathematics, English, computer science, and Korean for special education subjects from 2025. • Focusing on enhancing the digital competencies of educators, led by the T.O.U.C.H (Teachers who upgrade class with high-tech) teacher group. • Developing various teaching models using digital technology. • Establishing a collaborative system with the education department and operating digital beacon schools. • Expanding the digital infrastructure.
Latvia	National Development Plan 2021-2027 Education Development Guidelines 2021-2027 Digital Transformation Guidelines 2021-2027	Digital Transformation Guidelines 2021-2027 1. Digitalisation of teaching and learning processes (e.g. simulations, virtual labs); 2. Digitalisation of administrative processes (e.g. by creating a modular Information Systems architecture 3.Enabling digital services based on data analytics (e.g. personalised learning) 4. Ensuring the openness of educational data.
Lithuania	White paper on EdTech: White paper on EdTech	1. The preparation and validation of the necessary legislation and methodological material to define the minimum and/or target technological and digital standards for the use of digital content. 2, The introduction of the latest educational technologies in the education sector, enabling the development and testing of digital educational innovations. 3. Strengthening the digital competences of pedagogical staff. 4. The development of technological solutions, the necessary digital teaching, study resources in educational institutions in order to enable personalized distance learning not only in the conditions of the pandemic.
Luxembourg	Einfach Digital einfach-digital.pdfeinfach-digital.pdf	1. Information and Data: Careful and targeted selection of sources, evaluation, and critical use of information. 2. Communication and Collaboration: Mastery of the rules for safe and targeted communication and responsible use of media for collaboration. 3. Content Creation: Understanding media production possibilities and their creative and audience-appropriate implementation, knowledge of problem-solving strategies, and the basics of programming (or coding). 4. Data Protection and Security: Responsible management of one's

Country	Digital Education Strategy	Objectives
		own data and that of others, understanding the risks and dangers of digital environments, and taking appropriate security measures. 5. Digital Environment: Basic knowledge necessary for solving simple technical problems; the ability to use media discerningly and adopt a responsible and creative approach in one's own media interactions.
Mexico	Agenda Digital Educativa 2020 Agenda_Digital_Educacion.pdf (senado.gob.mx)	1. Teacher Training, Update, and Professional Certification in Digital Skills, Knowledge, and Competences. 2. Building a Digital Culture in the Community: Digital Literacy, Inclusion, and Digital Citizenship. 3. Production, Dissemination, Access, and Social Use of Digital Educational Teaching and Learning Resources. 4. Connectivity, Modernization, and Expansion of ICT Infrastructure. 5. Research, Development, Innovation, and Digital Educational Creativity.
Netherlands	Digitization agenda: Primary and secondary education Digitization+agenda+primary+and+secondary+education.pdf	• Teachers, school principals and administrators innovate by learning together and with others. • Students and teachers are digitally literate. • Digital learning resources work for the user. • Infrastructure is secure, reliable, and future proof. • There is a sustained focus on the ethics of digitization in education
New Zealand	Connected Ako: Digital and Data for learning Connected Ako	The Vision: • Learners and educators can thrive – live, learn and work – in the digital world • People are digital and data capable, contributing to personal, community and New Zealand's growth Learning, teaching, assessment, and research make best use of data and digital
Slovenia	Digital Education Action Plan (2021-2027)	1.National Coordination of Digital Education 2. Didactics of Digital Education 3. Modification of Educational and Study Programs, as well as Job Positions 4. Training and Development of Professional Staff, Leadership, and Other Educators, and Lifelong Learning 5. Ecosystem of Digital Education • Infrastructure: platforms, tools, services • educational e-content • management of educational institutions • internal and external progress evaluation • ensuring equality and equal opportunities • parental involvement and engagement of other stakeholders • cybersecurity • legal foundations for promoting digital education. 6. Protocols for Education in Special Circumstances
Spain	Plan de Digitalización y Competencias Digitales del Sistema Educativo Plan de Digitalización y Competencias Digitales del Sistema Educativo (Plan #DigEdu) - INTEF	1. Development of Educational Digital Competence (schools, teachers, and students). 2. Digitalization of the Educational Centre - Centre's Digital Plan. 3. Creation of Educational Resources in Digital Format. 4. Advanced digital methodologies and skills.
Sweden	N/A	
Türkiye	Turkey's Education Vision 2023	Digital content and skills-backed transformation of the learning process Goal1: An Ecosystem Will Be Created for Development of Digital Contents and Skills Goal 2: Content Will Be Developed and Teachers Will Be Trained for The Development of Digital Skills

Country	Digital Education Strategy	Objectives
United States	2024 US National Education Technology Plan National Educational Technology Plan - Office of Educational Technology	1. Engaging and Empowering Learning Through Technology 2. Teaching with Technology 3. Creating a Culture and Conditions for Innovation and Change 4. Measuring for Learning 5. Enabling Access and Effective Use
England (United Kingdom)	DfE Digital, Data and Technology (blog) DfE Digital, Data and Technology (blog.gov.uk) Realising the potential of technology in education (2019) Realising the potential of technology in education: A strategy for education providers and the technology industry (publishing.service.gov.uk) Digital, data and technology strategy: 2021 to 2024 Ofqual_Digital_Data_and_Technology__DDaT__Strategy-_2021-24.pdf (publishing.service.gov.uk)	*Realising the potential of technology in education (2019)* 1. Setting our vision for education technology 2. Securing the digital infrastructure 3. Developing digital capability and skills 4. Supporting effective procurement 5. Promoting digital safety 6. Developing a dynamic EdTech business sector 7. Supporting innovation through EdTech challenges 8. Improving the Department for Education's digital services
Flemish Comm. (Belgium)	Digisprong 40711 (vlaanderen.be)	1. A future-oriented and secure ICT infrastructure. 2. A strong, supportive, and effective ICT school policy 3. ICT-competent teachers and teacher trainers, and adapted digital learning resources 4. A knowledge and advice center 'Digisprong' serving the education field
French Comm. (Belgium)	Stratégie Numérique pour l'Education Stratégie du numérique pour l'éducation 2023-2027 | Ministère de l'Education Nationale et de la Jeunesse	1.Define the digital content and resources in support o f learning 2. Support and train teachers and school principals3. Define the equipment modalities for schools 4. Share, communicate, and disseminate 5. Develop digital governance.

Annex Table 14.A.2. Digital Education priorities in the next five years

Country	**Priorities in the next five years**
Austria	Under the 8-Point Plan, Austria continues to: • Increase provision of digital tools to all students and teachers • Foster digital skills and competences of people across all age groups • Encourage development of educational technologies and digital education resources. With the new package of measures for AI in school sector, Austria aims to provide a logical focus of the 8-point plan and address current challenges: 1. Establishment of AI Pilot schools: Learning and Teaching with AI Tools 2. Teaching materials – eduthek, digi.case and textbooks 3. Education, training and further education of teachers 4. AI in written work 5. Focus on AI in educational research 6. Digital school development in the field of AI
Brazil	-To improve data governance, portability, and interoperability to allow provision and dissemination of student information and education management systems.
Canada	-To strengthen the provision of digital infrastructures in provincial levels, such as: • student information system • implementation of digital exams and digital credentials • online educational platforms and resources.
Chile	-To increase and maintain the use of information systems available to schools by supporting pilot programmes that use classroom analytics technologies such as: • SIGE student information system

Country	Priorities in the next five years
	• SAE student admission system • SAT early warning system, etc. -To revise data protection regulations approaches along with a general interest in technology and data governance.
Czechia	Under the current national education strategy, Strategy 2030+ (“Strategie vzdelávací politiky Ceské republiky do roku 2030+”), published in 2020, aims to: • develop students’ skills to use technologies. • ensure adequate hardware, software, and connectivity. • strengthen teachers’ digital skills. • Improve teaching and learning by using technology to collect educational data for self and system evaluation. • improve communication between stakeholders.
Denmark	Setting a new direction for digitization in the education sector with a focus on: -Setting a new direction for digitization in the education sector with a focus on: • better digital coherence • IT security • new technology • technological literacy • competence enhancement of the teachers • better use of data
Estonia	-To support soft digital infrastructure such as: • online education platforms and digital resources for students and teachers • classroom analytics and other solutions for data collection and improvement of teaching • central level EMIS and SIS • digital credential system and digital exam administration • student admission management for upper secondary education and VET.
Finland	-To further develop KOSKI, the student information system, and Abitti, the digital system for administrating the matriculation exam -To connect different solutions of the digital ecosystem -To support the use of digital tools for a digitally skilled population.
France	Under the 2023-2027 Digital Education Strategy, France intends to: • Promote a digital ecosystem that serves a shared public policy – strengthen digital education to foster digital skills in citizens • Foster an educational community with appropriate and accessible digital tools • Develop a user-oriented ministry’s information system • Extend and strengthen the provision of online education platforms and digital resources. • Develop classroom analytics solutions.
Hungary	-To develop online education platform, provide digital resources for teachers and students, and collect data sources from all classroom level by: investing on digital infrastructure • investing on digital infrastructure • developing digital education resources such as textbooks and other materials to match the revised curriculum. • expanding all the administrative systems (including the ones operated by Hungary’s Educational Authority and the e-Kréta platform) to improve the quality of education data collected and to increase system resilience.
Iceland	-To provide more advanced types of digital tools, such as: • centralised online education platform. • classroom analytics technology in primary and lower education. • centralised system for student admission management.
Ireland	Under the most recent 2020-2027 digital education strategy, Ireland aims to further develop online education platforms, digital resources such as: • student information system and school management systems, • digital credential system for primary and secondary education • digital assessment, already being underway. • personalised tools to support learning and provide real-time feedback, such as intelligent tutoring systems, using AI in education.
Italy	Under the “Digital School 2022-2026" program, the government aims to: • Move educational services and applications to cloud solutions • Improve usability of digital services via adaptation to a standard model • Fasten the adoption of a centralised platform for accessing digital services and making payments • Encourage the adoption of single sign-on systems to increase interoperability between digital services
Japan	MEXT aims to continue: • Investment in hardware infrastructure and improvement in internet connectivity and internet quality. • Provision of digital devices for students at home and in schools.

Country	Priorities in the next five years
Korea	Korea's most recent digital strategy in 2023 specifies its interest in: • Supporting the shift of teacher's roles from lecturers to learning designers, coaches, and mentors • Creating an edtech ecosystem that promotes the co-development of education and the EdTech industry
Latvia	Establishing ICT infrastructure and provision of digital tools • Providing a computer to every student and teacher remains a priority, being its goal by 2025. • Establishing a computer library in schools is an additional goal.
Lithuania	-To develop online education platforms and digital teaching and learning resources, via more advanced digital teaching equipment -To improve already existing digital tools, such as SVIS, the student information system, LAMA SPO, the student admission management system, and the TAO, the online exam administration system - To enhance internet access and speed -To extend the learning management systems via data analytics for teachers -To connect digital credential system in higher education with VET institutions.
Luxembourg	-To improve the public digital education ecosystem by adding digital credential system in upper secondary education -To improve its online education platforms by developing its already existing Schouldoheem.lu platform -To provide intelligent tutoring systems by introducing classroom analytics tools.
Mexico	-To develop digital education agenda. -To increase interoperability and data portability between education institutions. -To further develop online digital education platforms and resources. -To improve its data and information systems.
Netherlands	-To improve digital infrastructural connectivity across regions -To improve data management and governance such as: • digital safety • digital competences • teacher autonomy • transparency and privacy
New Zealand	-To improve internet speed, provision of devices to teachers and students, allowing equitable access to internet and improving internet coverage and connectivity -To take advanced approaches to education technology • Weaving insights of tea o Māori and the power of digital and data. • A trusted data system can shape education for individuals, whānau, education organisations and system-wide improvement • Secure, future-ready digital solutions are accessible, streamlined, and cost-effective • Work across the sector and more broadly to bring coherence and leadership – including education providers, iwi, technology providers, business, and communities. • Using emerging trends and technologies to benefit learning and teaching, with expert scanning, planning, and training. • Learning, teaching, assessment and research can be transformed by digital and data to lift wellbeing, maximise capability and improve learning outcomes.
Slovenia	As a response to the COVID-19 Crisis, "Digital Education Action Plan 2021-2027 aims to address: • students' digital proficiency, • teachers' pedagogical skills in deploying digital technologies, • national coordination for digital education, • digital divide and related inequalities, • the quality of infrastructure for digital education.
Spain	• Provision of digital devices and improving connectivity remains priority in digital education. • Implementation of AI-powered platforms to enable personalised learning • Improvement of teacher competences and supporting their enhancement of digital skills to deliver digital education.
Sweden	-To improve provision of digital infrastructure, enhance data governance and regulation of digital technology in education in a provincial level. - To develop and implement digital national student evaluation through Sweden's national digital system for exam administration.
Türkiye	-To develop intelligent tutoring systems (ITS) -To strengthen its digital education platform (EBA) and its learning management system (e-Okul) by expanding the functionalities in EBA and continuously supporting the Safe Schooling and Distance Education Project (SSDE). - To provide interactive whiteboards and internet access to public schools.
United States	-To develop US digital hardware infrastructure, covering the provision of digital devices for students in institutions and of internet access - To improve effective use of technology in education - To develop online education platforms and resources - On the state level, to improve on specific digital resources such as classroom analytics, learning management systems, and student information systems - To establish a federal education R&D infrastructure to support state educational agencies to use evidence-based educational

Country	Priorities in the next five years
	practices.
(England) United Kingdom	• To continue invest in hardware infrastructure such as broadband and Wi-Fi connections in schools • To improve data governance by : • Setting standards on cybersecurity • Setting standards on filtering, monitoring • Making school leaders and all relevant stakeholders understand the need to maintain security and support online safety • To build a strong evidence base to use technologies effectively as well as embedding these evidences across all school systems
Flemish Comm. (Belgium)	-To develop and improve its provision of online educational platforms and digital resources. -To upgrade and generalise the use of Discimus (the student information system) -To provide a solution for digital assessment administration for the national student evaluation.
French Comm. (Belgium)	• Strengthen the provision (or its support to the provision) of: • Student information system and learning management systems. • A digital system for the administration of national student assessments. • Online education platforms and digital resources.

Notes

1 ‘Digisprong’ of the Flemish Community (europa.eu)

2 8-Point Plan for Digital Learning (bmbwf.gv.at)

3 Digital-Wallonia-V3-0-Texte-Complet-2022-09-01 (ctfassets.net)

4 Making the “digital leap” in Finnish schools – Tampere University Research Portal (tuni.fi)

5 Italy | Technology | Education Profiles (education-profiles.org)

6 download (president.lv)

7 Enrolment in general full-time schools by grades (at the beginning of the school year). PxWeb (stat.gov.lv)

8 See (OECD, 2023[4]), "Brazil".

9 New package of measures for AI in the school sector. Künstliche Intelligenz – Chance für Österreichs Schulen (bmbwf.gv.at)

10 Digital Strategies for Schools to 2027: https://assets.gov.ie/221285/6fc98405-d345-41a3-a770-c97e1a4479d3.pdf

11 brozura_S2030_en_fin_online.pdf (msmt.cz)

15 The role of support organisations in implementing digital education policies

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This chapter analyses how seven countries (six OECD members and Uruguay) have established agencies and organisations for the implementation of their digital education national policies, and how some of these organisations have been extinguished or evolved over time. Lessons are drawn from understanding changes in organisational structures set in place in countries with sustained national digital education policies, and the advantages and disadvantages of different models of support organisations is discussed.

Introduction

In face of the rapid advances of digital technology in all areas of society, governments are actively working to design, update and implement digital education policies. Most of these policies seek to harness the power of digital technologies to solve quality, equity and efficiency issues in educational systems, and to develop the digital skills perceived as fundamental for all citizens and for the competitiveness of countries (van der Vlies, 2020[1]).

The Global Monitoring Report-GEM published by UNESCO (2023[2]) states that the right to meaningful connectivity, and to digital learning, is increasingly synonymous with the right to education. Children and youth need to have access to learning opportunities that prepare them to lead active, productive and fulfilled lives, including the ones offered by digital technology.

The implementation of digital education policies is inherently complex for at least two reasons. First, it needs to integrate activities of different domains such as the provision of digital infrastructure in schools, the production and distribution of digital materials, and teachers' professional development. Second, these activities require different expertise than those traditionally available at ministries or national departments of education since multi-stakeholder partnerships need to be established, managed, and monitored.

Conceptual frameworks for planning Information and Communications Technology (ICT) policies in education have already been developed by multilateral organisations such as the World Bank and UNESCO (2022[3]). Less information and technical guidance is available on how to design organisational structures and support organisations needed to effectively implement such policies.

This chapter aims at analysing how seven countries (six OECD members plus Uruguay) have established agencies and organisations for the implementation of their digital education national policies, and how some of these organisations have been extinguished or evolved over time. Understanding changes in organisational structures set in place in countries with sustained national digital education policies can generate important lessons for governments with the urgent drive to effectively implement similar policies.

Methodology

Objective

This study aims to shed light on the changes and transitions that happened in a group of organisations or agencies created to support the implementation of national policies of digital education. The underlying assumption is that understanding changes in organisational arrangements for policy implementation will help countries to reflect on how to ensure effective implementation of their national policies.

The main questions are: what kind of organisational support helps make digital education policy reach schools and impact educational systems, and why have some countries changed the nature and mandate of their organisational support over different periods?

For the purpose of this study, the term national policy for digital education is used to refer to any policy at the national level created to foster the use of technology in public education at the primary and secondary levels.

Sources

The present study is based on three types of sources.

- Documents, websites, and official documents of the countries included in the analysis regarding governance and organisational structures dedicated to supporting the implementation of their national policies of digital education. A limitation of this type of source is that websites and updated information about support organisations that have been dismantled are no longer available.

- Policy documents and reports of international organisations that present a comparative analysis of different digital education policies and how countries set up organisational structures to implement them.
- Research papers published in national and international journals that look at the challenges of the implementation of digital education policies, particularly in terms of organisational structures and political factors.

A keystone for the elaboration of this study was the document "Building and Sustaining National Technology Agencies" published in 2017 by Michael Trucano and Gavin Dykes which defined and described organisations/agencies created in 11 countries for the implementation of digital education policies (Trucano and Dykes, 2017[4]). Although some of the organisations included in their study are no longer active, it identified and called attention to support organisations as an important element of the effective implementation of digital education policies.

Criteria for selecting the cases of support organisations

To contemplate political and geographical variation, an active search of support organisations in Latin America (Chile, Uruguay and Costa Rica), Europe (Estonia, Ireland, and The Netherlands), and Asia (Korea) was carried out. The main criteria for selection involved reported changes in the existence, internal structure, or mandate of these organisations.

Examples of other support organisations which are not included in the cases studies, such as the *British Educational Communications and Technology Agency* (Becta) in the United Kingdom, and Digital Promise in the United States, are provided in the discussion to illustrate specific elements or factors that may affect the implementation of digital education policies. The possible consequences of not having national support organisations are discussed in the context of Brazil.

Literature review

The literature review conducted for this study focused on three intertwined strands: the process of implementation and scaling up digital education policies, organisational structures needed to help governments to implement policies and roles of supporting organisations in the implementation of digital education policies.

Policy implementation in education can be defined "as a purposeful and multidirectional change process aiming to put a specific policy into practice and which affects an education system on several levels" (Viennet and Pont, 2017[5]). Implementing an education policy fundamentally consists in getting many actors or agencies to cooperate at various levels of the education system with a clear attribution of tasks to each actor. The distribution of tasks and responsibilities is determined by the institutional structure in place in each education system.

Evidence of the complexity and importance of effective policy implementation has been produced by academic researchers and multilateral organisations (Gouëdard, 2021[6]; UNESCO IIEP, 2003[7]; OECD, 2020[8]).

According to the report *Strengthening the Governance of Skills Systems: Lessons from Six OECD Countries,* implementation "is as important as the policy design itself, and is, in fact, a key aspect of the policy success in reaching schools and classrooms" (OECD, 2020[9]).

A recent paper about the challenges of implementing and scaling up educational initiatives in different countries argues that effective large-scale implementation takes a combination of technical expertise, understanding of local contexts, political strategy, collaborative partnership, flexible adaptation, and shared vision to scale and sustain the impact of education initiatives (Wyss et al. 2023).

In the specific case of digital education policies, or ICT in education, the level of complexity for implementation can be even higher. In his analysis of the potential of ICT policies to produce system-wide changes in education, Kozma (2008[10]; 2011[11]) warns about the fact that, while policy can facilitate change, it is not necessarily followed by implementation or impact. Michael Fullan makes a similar point when proposing that technology can only produce changes in education systems when policies contemplate three pillars: pedagogy, technology, and change knowledge (Fullan and Donnelly, 2013[12]).

Further contributing to the level of complexity in the implementation of digital education policies is the need to balance the timing of deployment and execution of very different processes. According to the "Four in Balance" model proposed by Kennisnet (2015), the effectiveness of digital educational policies depends on a balanced execution of activities in different dimensions such as planning, infrastructure, teachers' digital skills, and production of digital materials. According to this model deploying computers and connectivity to schools without providing training to teachers undermines the potential positive impact of technology in education.

Another challenge to the implementation of digital educational policies relates to governance. The European Commission's recommendations on key enabling factors for the provision of digital education include issues related to the governance of policy implementation and highlight the importance of ensuring cooperation and collaboration within government departments and with external stakeholders. The absence of a strong and effective co-ordination of the multidimensional activities involved in digital education policies may lead to a situation that, "despite progress and excellent examples of innovation, endeavours have not yet resulted in systemic digital transformation in education and training" (European Commission, 2023[13]). The same argument is presented in the OECD report on enabling factors of digital education policies which highlights the importance of the system's governance arrangements to facilitate co-ordination and alignment among stakeholders to improve the development and implementation of the policy (OECD, 2023[14]).

Lessons from ICT policies in the United Kingdom reported by Younie (2006[15]) acknowledge that implementation is a complex procedure, not a direct translation from government policy to practice. The study found that five areas were particularly problematic for ICT policy implementation: management, funding, technology procurement, ICT training, and impact on pedagogy. According to the author, implementation needs to be filtered and analysed at least three levels since digital education policies are usually mediated through national agencies (macro), regional agencies (meso) down to individual schools and teachers(micro). Therefore, governance and effective co-ordination among different instances are key. The complexity of implementation can also be attributed to the multi-agency nature of the initiatives and their leadership (Younie, 2006[15]). Dykes (2016[16]) also identifies political disputes and lack of clear governance in digital education policies as elements contributing to the dismantling of BECTA (British Educational Communications and Technology Agency), which was responsible for supporting the implementation of digital education policies in England until 2011.

In fact, Hudson et al. (2019[17]) argue that dispersed and weak organisational governance is one of the main contributors to policy implementation failure. Policies formulated at the national level may face the challenge of ensuring consistency of implementation at the sub-national level, which is difficult to do when the sub-national level has some political autonomy, as is sometimes the case of educational systems. They argue that one strategy to help the implementation of social policies (not exclusively education) is the creation of "implementation support centres, entities of various types that work alongside and often under the direction of government to support effective implementation".

Franks and Bory (2017[18]) develop a similar concept of "intermediary organisations" which, they conclude, "appear to play a critical role not only in implementing model programmes but also in developing the necessary capacity for systems change".

There is a growing understanding (Miao et al., 2022[3]; Tate and Greatbatch, 2022[19]) that effective implementation of digital education policies requires the creation, or adaptation, of specific organisational structures or institutions with the capacity to coordinate public and private actors and execute different activities (Kozma, 2011[11]; Miao et al., 2022[3]).

Countries have used different models and strategies for the implementation of digital education policies (Kozma, 2011[11]; UNESCO IIEP, 2003[7]). In some countries, the implementation of digital education policies is carried out by organisations/agencies which have been created for this specific goal or have taken over this responsibility by a delegation from the Ministry of Education.

In 2017 the World Bank published a report that investigated national educational technology agencies, and their functional equivalents, to understand how these organisations are structured, how they operate, and evolved over time. In describing the role of the ICT agencies in 11 countries, the authors concluded that they differ significantly in their structure, governance, and forms of funding, but all were instrumental in the implementation of ICT policies of education (Trucano and Dykes, 2017[4]).

The context has changed significantly since then. Countries like Chile and Estonia, for example, decided to discontinue their national ICT agencies and incorporate their functions back into the Ministry of Education. Meanwhile, other countries like Uruguay, the Netherlands, Costa Rica, and Korea invested more intensively in their national ICT agencies.

Understanding the changes that national ICT agencies underwent in recent years to better fulfil their role is important. The research on organisational personas or archetypes (Martínez-Román et al., 2020[20]; Damanpour and Schneider, 2009[21]), which looks at organisations according to their characteristics and goals can provide a useful framework for understanding some of the changes.

While researchers agree that no single pathway for effective implementation of digital education policies exists, it can be tempting to assume that, if national governments have the will and the budget, they will have the capacity to implement a digital education policy. This is in fact a difficult task. Regardless of the size and level of economic development of the country, governments face constraints related to time, human and financial resources. Understanding the role of ICT national agencies/support organisations in the implementation of digital education policies can help governments in creating organisational structures capable of ensuring that every student will have the opportunity to harness the learning innovations offered by digital education.

Definition and roles of support organisations for digital education policies

Since a support organisation can take many forms and functions in the implementation of digital education policies, for the purpose of this study the definition of support organisation will be comprehensive and based on their institutional role. A support organisation is defined as any institution within or outside government with the mandate of implementing public policies to promote digital learning and/or the use of technology in schools.

Trucano and Dykes (2017[4]) refer to such organisations as “national institutions emerging in countries around the world to help introduce, support, fund, share information about and evaluate the use of ICTs in education at a large scale”.

In its Guidelines for ICT Policies in Education, UNESCO (2022[3]) refer to “organisational structures” to govern and coordinate the implementation of ICT policies in education. The document states that such organisational structures may take the form of a central governing board with the authority to govern and oversee the policy implementation; a dedicated national ICT in education agency delegated to coordinate the implementation and manage collaborations; and a task team charged with implementing the policy".

Another helpful strategy to define the concept of support organisations is to look for how some of these organisations present themselves.

- In the Netherlands, *Kennisnet* presents itself as a public organisation for Education and ICT which provides a national ICT infrastructure, advises the education councils, and shares knowledge about ICT with primary education, secondary education, and vocational education and training.
- In Costa Rica, *Fondación Omar Dengo* is a private, not-for-profit organisation whose mandate is the development and increase of the quality of education, using computer science and the application of new technologies to educational processes (Jimenez Iglesias, 2016).
- In Korea, *The Korea Education and Research Information Service (KERIS)* states it is a public institution under the Korean Ministry of Education that promotes various projects and academic research related to Information and Communication Technology (ICT) in education ranging from primary to higher education.
- In Chile, the *Centro de Innovación del Ministerio de Educacion (CIM),* which incorporated former Enlaces, states as its mission to strengthen the innovation capacity of the education system using the potential of digital technologies to offer students learning experiences that promote their full development.
- In Estonia, the former *Information Technology Foundation for Education (HITSA)* which operated until 2020 and was incorporated by the Education and Youth Authority (HARNO) stated as its role to ensure that students from educational levels obtain the digital skills necessary for economic and societal development.
- In Uruguay, *CEIBAL* is the digital technology centre for education innovation at the service of public education policies. CEIBAL promotes the integration of technologies to improve learning and foster processes of innovation, inclusion and personal growth.
- In Ireland, the dedicated Digital Technology Division of Oide (formerly known as *PDST Technology in Education*) promotes and supports the integration of ICT in teaching and learning in schools. It is part of the national support service, Oide, the comprehensive Professional Development Service for Teachers created in 2023 (formerly known as and expanding the Professional Development Service for Teachers [PDST]), which operates under the aegis of the Department of Education and Skills.

The examples above demonstrate how heterogeneous support organisations can be in their legal incorporation and structure. They can take the form of:

- Public or private organisations.
- University Departments.
- Units or Departments inside or outside the Ministry of Education.
- Formal or informal structures (committees and task forces).

In the face of this comprehensive set of organisational features this paper will look at organisations that share a common goal: help governments to implement digital education policies at the national level.

Main functions of Support Organisations

There are a set of activities that support organisations may perform in order to help governments to implement digital education policies such as:

- Planning and elaboration of digital education/ICT masterplans and strategy documents.
- Acquisition, deployment, and maintenance of ICT infrastructure for schools (devices and Internet).

- Set-up and management of central infrastructure such as data centres and system-wide digital platforms.
- Promotion of teachers' professional development in digital skills.
- Development and distribution of digital educational materials.
- Monitoring and Evaluation of the implementation of digital education policies.
- Co-ordination of multiple partners involved in the digital education policy implementation.

These activities can be clustered according to their nature and the demand for investments and technical expertise they require.

For example, the acquisition, deployment, and maintenance of ICT infrastructure for schools, and management of central infrastructure such as data centres and system-wide digital platforms require specific expertise and significant investments in infrastructure. It also requires articulation with other government and private entities related to telecommunications and digital services. The professional team must include engineers, data scientists, and technology experts prepared to negotiate with public and private providers.

A second cluster includes activities such as planning, monitoring, and evaluation of digital education policies which require cross-disciplinary and academic expertise that includes knowledge of policy design and planning specific to the area of education.

A third cluster of activities is more related to education and pedagogy such as teachers' professional development in digital and related pedagogical skills and the development and distribution of digital educational materials. In this cluster, the activities require integration with the general national education policy, specific knowledge of the field of education, and legitimacy to work with school systems and teachers.

Moreover, there is the role of co-ordination of the different stakeholders involved in the implementation of the digital education policy, and the negotiation with private suppliers and partners. This role requires not only technical expertise but legitimacy and political mandate without reproducing the constraints of a government bureaucracy. Although digital education policies are usually coordinated by ministries of education, they depend on the active participation of other ministries as well as public and private partners. In some cases, the delegation of power to coordinate the digital education policy comes directly from the highest level of government, and the supporting organisation plays the role of an executive secretariat to monitor partners' activities and results.

Examples of support organisations

The case studies presented in Annex 15.A allow us to analyse support organisations for the implementation of digital education policies operating in diverse countries such as Chile, Costa Rica, Estonia, Ireland, Korea, the Netherlands and Uruguay.

The present study does not include a detailed description of each of the selected support organisation, which can be found on their website and other documents such as Kozma (2011[11]) and Trucano and Dykes (2017[4]).

The cases are described according to the following variables:

- Context and date of creation.
- Main functions.
- Changes/Transitions.
- Current functioning.
- Perceived advantages and challenges.

Discussion of cases

Common features of change/transition of support organisations

The analysis of the cases selected for this study allowed the identification of shared patterns of organisational structure and evolution among supporting organisations.

First, most of these organisations were created in the late 1980s and 1990s when there was a strong awareness of the need to use technology in education and to promote the development of 21st century skills among students. At the time most of the policies were called "ICT in education" and had a dual goal: improve the effectiveness and efficiency of educational systems and prepare citizens with digital skills which were deemed essential for national competitiveness. Estonia, Costa Rica, Uruguay and Ireland are good examples of the political commitment to make ICT a strategic driver for economic and social development.

The creation, evolution, and/or discontinuation of support organisations seem to be associated with changes in government and the launching of new policies about ICT in education, although few of these policies (Ireland and Korea are exceptions), explicitly determined the organisational structure needed for its implementation.

In general, the initial mandate of the support organisations was to create the digital infrastructure in schools and to articulate financial and technical resources from public and private sources mainly from Telecom companies. To meet this goal, flexible and independent organisational structures were considered more appropriate than governmental institutions. To illustrate this point, the creation of the Omar Dengo Foundation generated the following comment by Seymour Papert from the Massachusetts Institute of Technology (MIT) when providing technical guidance for the first "ICT in education" project in Costa Rica: *"The government of Costa Rica created a foundation to supervise the project – an unusual case in which the government itself made the decision of protecting a project from its own bureaucracy!"* (Bujanda Bujanda and Muñoz García, 2023[22]).

As the deployment of digital infrastructure in schools advanced or was completed, support organisations were asked to take a more active role in developing digital learning methodologies and materials, and in training teachers. In recent years, issues related to platform management, privacy, and security of educational databases were incorporated into the mandate of support organisations. Kennisnet and KERIS are good examples of how the development, acquisition, and distribution of digital content and management of educational databases have become top priorities in their organisational agenda. Trucano and Dykes (2017[4]) noticed the same trend in their analysis of national educational technology agencies and presented their evolution in five stages: starting (generally focused on the roll-out of computers and/or Internet connectivity to schools), expanding (scaling up the initial activities), evolving (taking-up news roles), sustaining (embedding into the system), and ending (in case of mission accomplished, failure or changing circumstances).

A parallel movement to the evolution of responsibilities of supporting organisations was the creation and/or strengthening of digital education units within countries' Ministry/Department of education. In some cases, such units gradually incorporated many of the functions initially performed by support organisations to the point that some of them were ultimately dismantled. In Chile, for example, the support to implement digital education policies evolved from an independent service provided by universities (Enlaces project) to a hybrid organisation (CET-Enlaces) and finally to the creation of a Centre of Innovation within the Ministry of education (CIM).

The case of Chile illustrates well the evolution from an external arrangement to an internal unit at the Ministry of Education with the responsibility of implementing not a specific ICT policy, but a digital component of a general educational policy. Severin (2017) argues that this evolution is important for the legitimacy and long-term funding of ICT in education policies, but that it also has its drawbacks, with increasing difficulties to develop bold and innovative strategies and the slowness of bureaucracy. Claro and Jara (2020[23]) also recognise that the integration of Enlaces to the Ministry of Education entailed a better articulation with the general education policy, but gradually restricted the renewal of the vision and the agenda of Chilean digital education policy.

Another similar trend can be observed regarding the nature and scope of the work of supporting organisations. In the last decade, organisational structures to support digital education policies evolved from organisations focused on technology to broad educational services providers. A good example in Ireland is the National Center for Technology in Education (NCTE) which was incorporated by the Professional Development Service for Teachers (PDST), which itself was incorporated in Oide, a public agency that provides: comprehensive educational services including curriculum and pedagogy; learning and teaching methodologies; school improvement and school self-evaluation; school leadership; pupil/student and teacher welfare and Information and Communications Technology. A similar movement happened in Estonia where HITSA, the Information Technology for Education Foundation, was incorporated by the Education and Youth Board (HARNO) which has six different departments of educational services including one dedicated to digital education. Nevertheless, countries like Uruguay, the Netherlands and Korea decided to keep the digital education agency separated from the general education service provider in order to maintain focus and drive for the digital transformation.

The new challenges of Support Organisations

The changes in the scope of supporting organisations seem to be related to the growing realisation that the role of technology is to promote innovation in educational systems, and not only to digitalise traditional teaching and learning practices. Therefore, support organisations may need to take up the responsibility of generating, systematising, and ensuring the adoption of innovations in educational systems both at the central and school level. This is a herculean task in public settings, which may require the sum of more than one organisational persona or archetype (Damanpour and Schneider, 2009[21]; Martínez-Román et al., 2020[20]).

Considering the clusters of activities performed by the supporting organisations analysed in the present study, and additional research on organisational structures, it is possible to identify three different personas or archetypes as roles to be performed by support organisations.

Personas/archetypes	Cluster of activities	Requirements/conditions
Service Provider	Deployment of digital infrastructure; management of digital platforms; technical support to schools	Long-term and high-budget contracts with the Ministry of Education and state and municipal governments, and a multidisciplinary team of professionals
Expert	Production of documents, methodologies, and processes to generate pedagogical innovations and assessment of policy interventions	Academic and professional knowledge applied to school contexts; research capacity; public policy expertise
Leader	Co-ordination, monitoring, and assessment of the activities of a wide range of partners, both public and private.	Official mandate and political clout to negotiate with public and private actors

Although it may be difficult to incorporate all three personas/archetypes in one single organisation, these are roles that need to be performed and should be contemplated when designing the organisational structure for the implementation of digital education policies. The concept of organisational consortiums, coalitions, and partnerships may present an innovative institutional arrangement to face the complexity of effectively implementing digital education policies. In any case the need of co-ordination is key.

Implications for digital education policies

An often-neglected element of digital education policies is the organisational structure needed to coordinate and support the implementation of their multidimensional set of actions. Digital education policies have a high level of complexity in their implementation because they must contemplate activities very different in scope and nature such as school infrastructure, production of digital content, and teachers' professional development.

Transforming ambitious digital education masterplans into real innovations in teaching and learning at the school level requires commitment, technical expertise, and funding from multiple public and private agents. Without clear attribution of responsibilities and mechanisms of accountability, the necessary balance between the implementation of complementary elements may not be achieved (Kennisnet, 2015).

Well-formulated strategy document and masterplan expressing a shared vision about the goals for the use of technology in education is a necessary first step and should involve multiple stakeholders of the educational ecosystem in its discussion and validation (van der Vlies, 2020[1]). But as important as the strategies to achieve each of the goals, is the design of the organisational structure for implementing them (Andrews, Pritchett and Woolcock, 2017[24]). Establishing the necessary organisational structure will probably involve mobilising and adapting existing institutions/agencies, but may also require the creation of a specific support organisation.

The roles to be performed by support organisations need to be adapted to the national context since they may vary considerably according to size of the country, the level of centralisation of the education system and the existence of other public and private actors in the digital education ecosystem.

The role of direct **service provider** to schools may be more adequate to support organisations operating in small countries such as Uruguay, Estonia and Costa Rica. In Uruguay, for example, CEIBAL is responsible for the acquisition, maintenance and distribution of devices and access to Internet directly to all teachers and students in the country. However, the capacity to be a direct service provider is not only related to the size of the country, but also to the level of decentralisation of educational services. In other countries such as the Netherlands and Estonia the provision of services to schools is more focused on educational platforms and data management since schools have autonomy and funding to acquire digital infrastructure. In large countries regional and local organisations may be more suited to provide direct infrastructure and services to schools. Countries like Estonia and Ireland have opted to incorporate their ICT support organisation into broad services providers organisations such as HARNO and Oide. Even when the focus of the support organisation is not on providing direct services to schools it is important that public policies design the organisational structure, and define co-ordination mechanisms, to ensure that all schools receive the services needed to implement digital education.

The role of **expert** contemplates several activities ranging from development, selection and distribution of digital content; teachers' training; management of learning and data systems, to monitoring and providing recommendations for improvements in the digital education policy. Expertise on defining interoperability standards, creating criteria for the selection of digital educational resources and management of learning platforms is not commonly found among professionals in the education ecosystem. The work of KERIS and Kennisnet are examples of how support organisations can contribute to ensure quality and alignment to curriculum of digital resources recommended to teachers and schools.

As support organisations are increasingly demanded to elaborate methodologies for innovative teaching and learning practices using technology, their work may overlap and create potential conflicts with other organisations responsible for pedagogical issues in the education ecosystem. This is reportedly the case in Uruguay and Costa Rica. In Chile, the end of Enlaces was justified as a strategy to integrate the digital component into the general education policy and avoid organisational overlap (Claro and Jara, 2020[23]). Although this integration is desirable, specific expertise in digital education teaching and learning practices needs to be ensured. Support organisations can maintain a team of experts for developing guidelines and training teachers on innovations using technology.

Another important activity that requires expertise is monitoring and assessment of digital education policies looking both at the implementation process and results. Monitoring and assessment are components traditionally missing in most digital education policies (OECD, 2023[14]). Support organisations may work as experts in developing the indicators, collect and analyse data about the level of implementation and the use of technology in schools.

The role of **leader** of a digital education policy should be performed by the Ministry of Education at the political level, but may require at the operational level a specific organisation with mandate to develop the general conceptual framework and coordinate the activities of all actors involved. Leadership in implementation of digital education policies is key and should be synonymous of accountability (Andrews, Pritchett and Woolcock, 2017[24]). The operational leadership of a support organisation is vital to ensure the continuity of the digital education agenda and its respective budget, and to develop and retain a team of experts and practitioners working for the education system. Countries that have implemented a long-term digital education policy such as Estonia and Korea have established support organisations.

It Is also interesting to analyse countries that do not have national support organisations for the implementation of digital education policies. Brazil and the United States are good examples.

The United States has a highly decentralised education system with multiple organisations providing technical support on digital education to districts and schools such as Digital Promise, the International Society of Technology in Education (ISTE), The Consortium for School Networking (CoSN) and the State Educational Technology Directors Association (SETDA). Digital Promise may be the closest to the model of support organisation as defined in this study since it was authorised by Congress in 2008 and received initial funding from public and private partners. But since then, Digital Promise has operated more as an independent NGO with specific projects for school districts, schools, companies and other organisations, although maintaining a close relationship with the US Department of Education.

In Brazil, the central government is responsible for setting general educational policies and supporting states and municipalities in their implementation. Although there is a national ICT policy (PIEC, 2021) and a digital education strategy (PNED, 2023) approved by Congress there is no articulated organisational structure to support their implementation. The lack of central co-ordination compromises the effectiveness and efficiency of investments in digital education and creates more educational inequality. Data from the Center of Innovation for Brazilian Education (CIEB) shows significant variation in the level of adoption of technology among Brazilian schools (Centro de Inovação para a Educação Brasileira (CIEB), 2022[25]; Centro de Inovação para Educação Brasileira (CIEB), 2015[26]), which indicates that states and municipalities depend only on their organisational capacity and local partners.

Currently, considerable funds are being allocated to digital education from public and private sources, including the Telecommunications Universal Service Fund (FUST). Moreover, a new organisation (EACE) was created to connect all schools with funds from the 5G public concession. A coalition of foundations and NGOs provide support to the national, state, and municipal governments on the implementation of digital education. But these efforts would benefit from a devoted non-ministerial central co-ordination that could easily engage with private and public actors: this would allow optimising human and financial resources and avoid the duplication of efforts among stakeholders.

The existence of a support organisation does not guarantee the effective implementation of a digital education policy though. Support organisations can be discontinued due to political decisions or have their funding redirected to other government goals. They can become too attached to one model of use of technology in education and lose their capacity to generate educational innovations. Their work can overlap with other educational agencies and create institutional conflicts. But as presented in this study, the benefits of having a clearly defined organisation for the implementation of digital education national policies, working in partnership with a strong unit at the Ministry of education, seem to be a key enabler for the sustainability and effective implementation of such policies.

Pointers for Policy makers

Creating, implementing and sustaining an effective digital education policy is a complex endeavour which requires political commitment, technical expertise and significant funding. But it is an unavoidable responsibility for education leaders and policy makers all over the world.

The responsibility of policy makers is to design and implement effective digital education policies that generate results for learning. Considering all the investments in technology that have not been able to produce such results, it is wise to learn from the experience of countries where digital education has been implemented in a consistent and sustainable way.

Based on the seven cases analysed in this study, support organisations seem to constitute a key enabling factor for the implementation of digital education policies. Support organisations may provide services to schools, develop conceptual frameworks, coordinate and monitor the implementation of digital education policies.

However, there is no single organisational model that would serve all countries. The effective implementation of any educational policy is highly dependent on governments' capability and established organisational structures.

Therefore, before considering the creation of a support organisation for the implementation of a digital education policies, it is important to address the following questions:

1. Are there existing organisations that perform the role of service provider, expert and /or leader on digital education at the national level?
2. Could any of the existing organisations be adapted to assume the role of a support organisation for the implementation of the digital education policy?
3. Considering the size of the country and the level of decentralisation of the education system, what digital services should/could be provided to schools?
4. Does the regulatory environment of the country allow for the creation of an organisation of public interest with flexibility and accountability to establish partnerships with multiple stakeholders?
5. Would procurement processes conducted by the organisation be more agile when using public funds?
6. Is it possible to allocate long-term funding and establish accountability mechanisms to the work of support organisation?

The answers to these questions should frame and inform the decision to create, or not, a support organisation for the implementation of digital education policies. In case the benefits of creating a support organisation are expected, policy makers should consider the following recommendations:

1. Include in the design of a digital education policy the organisational structure that will be responsible for implementation. Determine the governance model and identify/create a supporting organisation capable of performing the roles of leadership, technical expertise and service provider to the educational system and/or schools.

2. The budget of the digital education policy needs to contemplate adequate and long-term funding for the activities of the support organisation. Disbursements should be linked to achievement of key performance indicators (KPIs) in the implementation of the digital education policy.
3. The Ministry of education should be the political leader of the digital education policy in order to ensure the integration to other educational policies. But, where appropriate, it should grant the mandate and autonomy to the supporting organisation to be the technical expert in digital education and coordinate the negotiations with public and private partners.
4. The role of technical expertise to propose pedagogical innovations and generate evidence about the use of technology in education may be performed through partnerships with universities. But a support organisation should have a highly qualified technical team capable of translating academic research into practical guidance to schools.
5. The role of service provider depends on the size and level of centralisation of the educational system. The range of services to be provided by a support organisation may include technical assistance to states and municipalities and direct operation of acquisition, delivery and management of digital infrastructure and software.
   - In large and decentralised educational systems supporting organisations may provide services at the national level such as the establishment of minimum parameters for digital infrastructure in schools, the elaboration of technical specifications for procurement of devices and connectivity; references for the inclusion of digital skills in the curriculum and methodologies for teachers' professional development. They can also manage national platforms of digital learning resources and establish the parameters of software safety and interoperability in educational systems. In this context the focus of support organisations should be on providing guidelines and technical assistance to states and municipalities in the implementation of the digital education policy.
   - In smaller and more centralised educational systems support organisations may offer direct services to schools. They can acquire, distribute and maintain digital infrastructure in schools, provide digital learning content aligned to the national curriculum and provide teachers' training in new teaching methodologies using technology. In order to offer such a wide range of services, support organisations should create decentralised units across the country or hire local partners to offer the services to schools.
6. Technical expertise is also necessary to establish tangible indicators, to monitor and evaluate the process of implementation of the digital education policy. An external organisation should be hired to conduct evaluation of the key performance indicators related to the expected results of the policy, and to the work of the support organisation.
7. In case of clear evidence of low performance of the support organisation the Ministry of education should be able to propose changes and even discontinue the funding. A new selection/procurement process should be conducted to identify a substitute supporting organisation for the implementation of the digital education policy.
8. Digital education policies should not be considered as a special or temporary initiative. Educational systems will need continuous technical and operational support to effectively incorporate technology for teaching and learning. Therefore, funding for support organisations should be included as a permanent rubric in the general budget of ministries of education.

References

Andrews, M., L. Pritchett and M. Woolcock (2017), *Building State Capability: Evidence, Analysis, Action*, Oxford University Press. [24]

Brenes, M. et al. (2014), *Las políticas TIC en los Sistemas Educativos de América Latina: Caso Costa Rica*, UNICEF. [34]

Bujanda Bujanda, M. and L. Muñoz García (2023), *Costa Rica's Omar Dengo Foundation Program: 29 years later*. [22]

CEIBAL (2006), *Aprendiendo del futuro*, https://ceibal.edu.uy/wp-content/uploads/2022/12/Learning-from-the-future.pdf. [36]

Centro de Inovação para a Educação Brasileira (CIEB) (2022), *Relatório Guia Edutec - Diagnóstico do Nível de Adoção de Tecnologia nas Escolas Públicas Brasilieiras em 2022*, https://cieb.net.br/wp-content/uploads/2022/12/2022-12-12-Relatorio-Guia-Edutec.pdf. [25]

Centro de Inovação para Educação Brasileira (CIEB) (2015), *CIEB: notas técnicas #1: A importância de políticas nacionais e centros de inovação em educação*, https://cieb.net.br/wp-content/uploads/2020/08/CIEB-Notas-Tecnicas-1-A-Importancia-de-Politicas-Nacionais-e-Centros-de-Inovacao-em-Educacao_v_CC.pdf. [26]

Claro, M. and I. Jara (2020), "The end of Enlaces: 25 years of an ICT education policy in Chile", *Digital Education Review*, Vol. 37, http://greav.ub.edu/der/. [23]

Damanpour, F. and M. Schneider (2009), "Characteristics of Innovation and Innovation Adoption in Public Organizations: Assessing the Role of Managers", *Journal of Public Administration Research and Theory*, Vol. 19/3, https://doi.org/10.1093/jopart/mun021. [21]

Dykes, G. (2016), "Building and sustaining national ICT education agencies: Lessons from England (Becta)", *World Bank Education, Technology & Innovation: SABER-ICT Technical Paper Series*. [16]

Education Estonia (2020), *Education Estonia*, https://www.educationestonia.org/contact/. [27]

European Commission (2023), *Proposal for Council Recommendation on the key enabling factors for successful digital education and training*, https://education.ec.europa.eu/document/proposal-for-council-recommendation-on-the-key-enabling-factors-for-successful-digital-education-and-training. [13]

Franks, R. and C. Bory (2017), "Strategies for Developing Intermediary Organizations: Considerations for Practice", *Families in Society*, Vol. 98/1, https://doi.org/10.1606/1044-3894.2017.6. [18]

Fullan, M. and K. Donnelly (2013), *Alive in the Swamp Assessing Digital Innovations in Education*, https://michaelfullan.ca/wp-content/uploads/2013/06/13_Alive_in_the_Swamp.pdf. [12]

Gouëdard, P. (2021), "Developing indicators to support the implementation of education policies", *OECD Education Working Papers*, https://doi.org/10.1787/b9f04dd0-en. [6]

Haridus- ja Noorteamet (2023), *HARNO - About, news, contacts*, https://harno.ee/harno-tutvustus. [30]

HARNO (2023), *ProgeTiigri programm*, https://www.harno.ee/progetiigri-programm#koostoopartnerid. [29]

Hudson, B., D. Hunter and S. Peckham (2019), "Policy failure and the policy-implementation gap: can policy support programs help?", *Policy Design and Practice*, Vol. 2/1, pp. 1-14, https://doi.org/10.1080/25741292.2018.1540378. [17]

Jimenez Iglesias, C. (2016), "Building and sustaining national ICT/education agencies: Omar Dengo Foundation", *World Bank Education, Technology & Innovation: SABER-ICT Technical Paper Series*, Vol. 13, https://openknowledge.worldbank.org/server/api/core/bitstreams/c9b35e74-8d47-5e61-98fa-29cd66c0bfe9/content. [33]

Kerssens, N. and J. van Dijck (2021), "The platformization of primary education in The Netherlands", *Learning Media and Technology*, Vol. 46/2, pp. 1-14, https://doi.org/10.1080/17439884.2021.1876725. [32]

Korea Education and Research Information Service (2021), *2021 White Paper on ICT Education in Korea*, https://www.keris.or.kr/eng/cm/cntnts/cntntsView.do?mi=1188&cntntsId=1334. [31]

Kozma, R. (2011), *The Technological, Economic, and Social Contexts for Educational ICT Policy*, UNESCO, https://unesdoc.unesco.org/ark:/48223/pf0000211842. [11]

Kozma, R. (2008), *Comparative Analysis of Policies for ICT in Education*, https://doi.org/10.1007/978-0-387-73315-9_68. [10]

Martínez-Román, J. et al. (2020), "Empirical analysis of organizational archetypes based on generation and adoption of knowledge and technologies", *Technovation*, Vol. 96-97, https://doi.org/10.1016/j.technovation.2020.102145. [20]

Miao, F. et al. (2022), *Guidelines for ICT in education policies and masterplans*, UNESCO, https://unesdoc.unesco.org/ark:/48223/pf0000380926. [3]

Ministry for Education and Science of Ireland (1998), *Ireland Schools I.T 2000: Full Report*, https://assets.gov.ie/24665/6bb0ea96e5944d12a39a0fe44ef14c61.pdf. [35]

OECD (2023), "Shaping Digital Education: Enabling Factors for Quality, Equity and Efficiency", https://doi.org/10.1787/bac4dc9f-en. [14]

OECD (2020), "An implementation framework for effective change in schools", *OECD Education Policy Perspectives*, https://doi.org/10.1787/4fd4113f-en. [8]

OECD (2020), *Strengthening the Governance of Skills Systems: Lessons from Six OECD Countries*, OECD Publishing, https://doi.org/10.1787/3a4bb6ea-en. [9]

Republic of Estonia - Minister of Education and Research (2019), *HITSA - Information Technology Foundation for Education*. [28]

Tate, S. and D. Greatbatch (2022), *International evidence on decision making on technology*, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1078471/International_technology_decision_making.pdf. [19]

Trucano, M. and G. Dykes (2017), *Building and sustaining national educational agencies: Lessons, models and case studies from around the world*, The World Bank, https://www.worldbank.org/en/topic/edutech/publication/building-and-sustaining-national-educational-technology-agencies-lessons-models-and-case-studies-from-around-the-world. [4]

UNESCO (2023), *Global education monitoring report, 2023: technology in education: a tool on whose terms?*. [2]

UNESCO IIEP (2003), *ICT in education around the world: trends, problems and prospects*, https://unesdoc.unesco.org/ark:/48223/pf0000136281?posInSet=9&queryId=7312ef93-b58b-43e4-bc2e-7e48ca3f607a. [7]

van der Vlies, R. (2020), "Digital strategies in education across OECD countries: Exploring education policies on digital technologies", *OECD Education Working Papers*, No. 226, OECD Publishing, Paris, https://doi.org/10.1787/33dd4c26-en. [1]

Viennet, R. and B. Pont (2017), "Education policy implementation: A literature review and proposed framework", *OECD Education Working Papers*, https://doi.org/10.1787/fc467a64-en. [5]

Younie, S. (2006), "Implementing government policy on ICT in education: Lessons learnt", *Educ Inf Technol*, Vol. 11, pp. 385-400, https://doi.org/10.1007/s10639-006-9017-1. [15]

Annex 15.A. Case Studies

Case 1. Chile: Centro de Innovación (CIM) < CET ENL < Enlaces

Context and date of creation

Enlaces (https://www.innovacion.mineduc.cl) was created in 1992 as a pioneer project in Latin America to explore the use of technology within a larger government initiative, partly funded by the World Bank, to improve quality and equity in Chile's education. The project was initially coordinated by a multidisciplinary team of the Institute of Computer Education at the University of La Frontera and served a small number of schools in a poor region of the country. At its beginning, Enlaces had unstructured institutional relationships although it was totally funded by the Ministry of Education. In 2005, part of the Enlaces project was incorporated by a unit within the Ministry of Education called the Center for Education and Technology (CET-Enlaces). In 2018 a new government administration extinguished CET-Enlaces and created the Center of Innovation (CIM) at the Ministry of Education with a broader mandate of promoting educational innovation.

Main functions

- Deployment of infrastructure for schools (computers).
- Development of digital learning materials.
- Training of teachers to use technology as means to improve teaching and learning.
- Technical and pedagogical assistance to schools.

Changes-Transitions

The presentation of the institutional arrangements in Chile for the implementation of digital education policies can be organised in three phases:

- First Phase (1992-2005): a project coordinated by the University of La Frontera, and later by a network of Universities (RATE) that worked as regional centres and executing units of the ICT in education policy.
- Second Phase (2005-2018): the Ministry of education formalises an internal unit called the Center for Education and Technology (CET-Enlaces) which had as many as 50 professionals (many coming from partner universities). For the first time, a national evaluation specifically designed to measured digital skills (SIMCE-TIC) was conducted with students and teachers.
- Third Phase (2018-): a new government administration extinguished CET-Enlaces and creates the Center of Innovation at the Ministry of Education. The new centre proposes a new approach with a strong focus on pedagogical innovations. The only activity maintained from Enlaces was the investment in school infrastructure, particularly in connectivity.

Current functioning

Nowadays the Center of Innovation (CIM) of the Ministry of Education has a team of 30 professionals at the headquarters and 16 regional coordinators. CIM is responsible primarily for the strategic goal of digital education under the Strengthening Learning, one of the 3 strategies of the general educational policy Plan de Reactivación Educativa. CIM organises its activities around three main lines:

- Educational Innovations.
- Educational digital Infrastructure.
- Technological Innovations.

Advantages and Challenges of the support organisation

Policy/organisational structure	Advantages	Challenges
Enlaces: University model.	Autonomy and flexibility to design activities for the use of technology in education; Actions guided by research evidence.	Lack of institutionalisation and unpredictable sources of funding.
CET Enlaces: Hybrid model.	Broader engagement with different stakeholders.	Diffuse governance between government and universities and weak institutionalisation.
CIM: Ministry Unit.	Integration with other educational policies and sources of funding.	Decreased agility when implementing actions due to administrative processes.

Case 2. Estonia: HARNO The Education and Youth Board < HITSA < A Tiger Leap Foundation

Context and date of creation

Support organisations for the implementation of Estonia's acclaimed digital education policies have changed considerably in the last decades moving from external bodies with a specific focus on ICT to general education government agencies.

Changes-Transitions

Tiger Leap Foundation (1997-2013)

The first ICT policy support organisation in Estonia was the Tiger Leap Foundation created in 1997 by the Ministry of Education as an independent agency. The foundation was a public-private partnership among the Estonian Government, ten private companies, an association of Estonian computer companies, and 26 individual experts. The foundation had as its main goal the implementation of the Tiger Leap Programme, a national development programme organised along three main pillars: provision of computers and Internet to all schools, teachers' training, and production of digital materials in the Estonian and Russian languages (Education Estonia, 2020[27]).

The Tiger Leap Foundation was responsible for providing technical support and complementary funding for ICT investments in schools. Although its activities included teachers' training and digital educational resources, more than two-thirds of its funds were invested in the ICT infrastructure. By the end of 2000, access to computers and the Internet was no longer the main issue, and the organisation begun to plan and implement more comprehensive activities to develop students and teachers' digital skills (Laanpere, 2002). In 2014, the Tiger Leap Foundation was transformed into HITSA Information Technology for Education Foundation.

HITSA Information Technology for Education Foundation (2014-2020)

HITSA (2019[28]) was founded with new partners including the Republic of Estonia, the University of Tartu, Tallinn University of Technology, Eesti Telekom, and the Estonian Association of Information Technology and Telecommunications. HITSA operated as the implementing "arm" of the Ministry of Education and Research for developing and deploying new technological solutions in schools, while also engaging other stakeholders, such as universities and companies (OECD, 2023[14]). It operated as the official helpdesk for different education online tools developed by the Ministry of Education and Research. HITSA was also responsible for training educational technologists who are experienced teachers who have completed a master's degree to become technology integration specialists at Estonian schools.

HARNO (2020-)

On August 1, 2020, HITSA activities were incorporated into the Education and Youth Board- HARNO (https://harno.ee). The Ministry of Education and Research decided to merge several institutions and foundations into one government agency called the Education and Youth Board (HARNO) with the mission of supporting the implementation of its policies. HARNO was established based on a merger of the services of the Innove Foundation, Archimedes Foundation, Information Technology Foundation for Education (HITSA), and Estonian Youth Work Center. HARNO is responsible for a broad range of activities from primary education to higher education, including providing tools for learning and teaching, and international relations to promote the Estonian educational model. HARNO has currently eight different departments for general educational services, and the digital education programmes are under the Department of Innovation and Cooperation (HARNO, 2023[29]) .

Main activities

HARNO's specific activities related to digital education:

- Co-ordination of the "ProgeTiigr" program, an evolution of the Tiger Leap Program, to develop learner'' digital competence and technological literacy.
- Support for the development of digital competence and technological literacy of teachers and supervisors and the promotion of professional networks.
- Co-finance the acquisition of necessary equipment for schools.
- Co-ordination of IT Academy, a cooperation platform to articulate entrepreneurs, universities, and schools.

Current functioning

HARNO currently has eight departments and two affiliated agencies, which employ over 400 people, to fulfil its ambitious mission of offering "Estonian people high-quality, modern, and equally accessible educational opportunities" (Haridus- ja Noorteamet, 2023[30]).

The digital education programme is under HARNO's Department of Innovation and Cooperation with the broadly defined goal of encouraging, developing, and testing innovations in the field of education and youth. It works with partners to introduce innovative learning, including digital materials and methodologies, and updates and enforces IT education at all levels of education.

Advantages and Challenges of the support organisation

Policy/organisational structure	Advantages	Challenges
Tiger Leap Foundation.	The capacity for rapid implementation of an initiative that had political commitment and diverse sources of funding; Alignment with the government economic development policy.	Lack of capacity to support use of deployed infrastructure
HITSA.	Focus on developing pedagogy and support of educational technologists in schools.	Weak institutional basis.
HARNO.	Integration with other educational policies.	Broad focus beyond digital education.

Case 3. Korea: KERIS < KMEC-KERIS

Context and date of creation

KERIS (https://www.keris.or.kr/) (Korea Education and Research Information Service) is a public organisation created in 1999 by the Ministry of Education, Science, and Technology of Korea following its first Master Plan for Informatisation of Educational Services launched in 1996 with an explicit focus on building an ICT infrastructure for education (Kwon and Jang, 2017). Since then, six other master plans for ICT in education have been launched in Korea and KERIS activities broadened considerably to include methodologies and digital educational materials, the creation and management of the education data centre, and training in digital skills for educational professionals.

Main functions

Among the main activities developed by KERIS, are:

- Building and operating digital learning platforms for all levels of education.
- Building an ecosystem for digital educational resources, which includes the standardisation and certification of digital content and procurement processes with vendors.
- Management of the National Education Information System (NEIS).
- Establishment and operation of administration and finance system of regional offices of education.
- Operating a research information-sharing system.
- Operating the Education Data Center.

Changes-Transitions

KERIS was created in 1999 as a merger of two specialised institutions that had been created in 1996 by the Ministry of Education, Science, and Technology: Korea Multimedia Education Center (KMEC) and the Korea Research Information Center (KRIC). KMEC had the role of running EDUNET, the first online education service in the country for elementary and secondary schools. KRIC was established to digitalise existing research and education information, build a national research information database, and provide an information retrieval service. As the use of ICT increased in all public policies in Korea the Ministry decided to create, by law, a new organisation that could integrate all operational activities related to the use of technology in education.

Since the creation of KERIS, the Ministry of Education has gone through different organisational structures (for example, it no longer includes Science and Technology) but has a special bureau for digital education that works closely with KERIS. The Minister of education appoints the president of KERIS and allocates the budget of the organisation. Interestingly, the first presidents appointed to KERIS were professionals from the ICT area, but, more recently, professionals from management and pedagogy have assumed the role which reflects the evolution and breadth of the activities performed by the organisation.

Current functioning

KERIS (Korea Education and Research Information Service, 2021[31]) is a key partner in the "Digital-based Education Innovation Plan" announced by the Ministry of Education in February 2023. Together with the Ministry of Education, KERIS is promoting key issues in digital education, such as supporting the development of AI digital textbooks, operating a programme to train "digital-leading teachers", and fostering EdTech to support public education. Previously, was developing the K-EDU Platform to integrate students' data across all digital education activities through the use of AI techniques, one of the main activities of the previous 2021 Informatization Strategy Plan (Korea Education and Research Information Service, 2021[31]). According to its president, KERIS will continue to lead innovation in education in Korea using ICT to improve teaching and learning methods and create a new educational environment.

KERIS also supports international cooperation in digital education, helping countries to establish and manage national digital education policies.

Advantages and Challenges of the support organisation

Policy/organisational structure	Advantages	Challenges
KERIS.	Secured and substantial government funding; Strong articulation with a well-established unit of digital education within Ministry of education; Integration of the different dimensions of ICT in education policy.	Limited autonomy to start new initiatives;

Case 4. The Netherlands: Kennisnet

Context and date of creation

Kennisnet (https://www.kennisnet.nl/) was founded in the Netherlands on 2 November 1998 as a public organisation to promote and support the use of ICT in education in the Netherlands. Its goal is to empower educational institutions and educators with the tools and knowledge necessary to effectively integrate technology into teaching and learning processes. Kennisnet provides a wide range of services, resources, and expertise to support schools in leveraging technology for educational purposes.

Kennisnet is funded by and maintains a close relationship with the Ministry of Education, Culture and Science in the Netherlands. The ministry provides strategic guidance and oversight to Kennisnet, and they work together to advance the use of ICT in education. Kennisnet aligns its activities with the objectives and initiatives of the ministry to support the implementation of these policies, but also proposes frameworks and guidelines for the elaboration of policies for ICT use in basic education. Kennisnet's conceptual framework "Four in Balanc" highlights the importance of balance among four elements (vision, expertise, digital resources, and infrastructure).

Main functions

Kennisnet offers a variety of services to support educational institutions, teachers, and students in the Netherlands. Some of the key services provided by Kennisnet include:

- Digital Learning Resources: Kennisnet provides access to a wide range of digital learning resources, including educational software, online courses, e-books, interactive learning materials, and multimedia resources.
- Infrastructure and Connectivity: Kennisnet supports schools in establishing and maintaining reliable and secure ICT infrastructure and connectivity. This includes assistance with network set-up, Internet connectivity, data management, and cybersecurity measures.
- Professional Development: Kennisnet offers professional development programmes, workshops, and training sessions for teachers and educational staff.
- Research and Innovation: Kennisnet conducts research and provides insights into the effective use of ICT in education.
- Online Platforms and Services: Kennisnet operates a single sign-on to various online platforms and services.
- Digital Safety and Privacy: guidance to schools on topics such as data protection, online safety for students, and responsible use of technology.
- Monitor and evaluate the use of ICT in schools through an annual survey.

Changes-Transitions

Although Kennisnet has not experienced a major organisational change since its foundation, other organisations have been created in the Netherlands to support digital education policies. Kennisnet works in partnership with these organisations to expand the breadth of digital support to schools.

For example, SURF (https://www.surf.nl) is an association of Dutch educational and research institutions that focuses on higher and vocational education. Kennisnet and SURF coordinated the public-private partnership, which involved providers of digital educational resources, distributors, and educational publishers, to create a unique identifier for students and teachers in the “educational content chain” (Kerssens and van Dijck, 2021[32]).

Another organisation to support digital education is SIVON (https://sivon.nl), created in 2017 as a cooperative of and for primary and secondary schools which offers joint tendering for ICT products and services. Kennisnet and SIVON have complementary roles in providing integral support to school boards in primary education. Kennisnet supports a national ICT infrastructure and the sharing of general knowledge of digital education while SIVON offers tailor-made solutions and support to schools.

Current functioning

Kennisnet continues to offer a wide range of services to primary and secondary schools in the Netherlands. The most recent services are related to data security and privacy regulations in the use of technology in schools. Kennisnet also stimulates school autonomy by offering services such as a platform that helps school boards to negotiate and process agreements directly with ICT vendors, and an App checker that gives teachers information about potential risks of any digital material they want to use in their classroom. Kennisnet has also consolidated its leadership in the co-ordination of multi-stakeholder partnerships, for example during the creation of the single sign-on for students and teachers across the digital educational ecosystem.

Advantages and Challenges of the support organisation

Policy/organisational structure	Advantages	Challenges
Kennisnet.	Budget secured by the ministry; Strong articulation with a well-established unit of digital education within the ministry; Partnerships with other private and public organisations that offer digital education support to schools.	Limited degree of autonomy to implement new activities; Potential overlap and competition with other organisations providing digital education support.

Case 5. Costa Rica: Fundación Omar Dengo

Context and date of creation

The Omar Dengo Foundation (FOD) (www.fod.ac.cr) is a non-governmental, private, non-profit organisation established in 1987. Since then, its mission has been to contribute to the improvement of the quality and equity of learning opportunities through innovative educational methodologies and the use of digital technologies (Jimenez Iglesias, 2016[33]).

The Foundation was created by the Costa Rican government with the mandate to implement the Programme of Educational Informatics of the Ministry of Public Education (PRONIE MEP-FOD MEP) which aimed at improving the quality of education through the use of informatics and the application of new technologies in the education system.

The establishment of a non-profit organisation to lead and execute a project like PRONIE MEP-FOD had several reasons, but mainly it had financial and administrative motivations: the legal structure of the foundation allowed for greater flexibility and operational agility, and facilitating the process of attracting external funding (Brenes et al., 2014[34]).

Main activities

FOD developed the following activities in the implementation of the national digital education policy (PRONIE,1998-2023):

- The creation of educational models for the development of 2[1s]t century strategic skills in students and teachers.
- Technological equipment and technical support to schools.
- Teacher professional development.
- Advisory and support for administrative staff and teachers at schools.
- Monitoring, evaluation, and research activities to track projects and incorporate new national or international perspectives into education.

Changes-Transitions

The role of FOD for the last 36 years has been to ensure the implementation of the national digital education policy in Costa Rica. However, with every change in government, the FOD had to negotiate priorities and seek alignment with the Ministry of Public Education (MEP).

In its early stages, FOD's work focused on the acquisition of digital infrastructure (connectivity and devices) for primary schools, which was mainly financed by external sources such as the United States Agency for

International Development (USAID). In 2002 with increased financial support from the Costa Rican government, the PRONIE MEP-FOD program was expanded to secondary schools.

FOD's work gradually expanded to include teachers' professional development of digital skills and the elaboration of pedagogical models integrating digital technologies into the core curriculum and general teaching practices.

The new government of Costa Rica has decided to create and implement a new digital education policy (to be implemented in 2024) in which the role of FOD has yet to be determined.

Current functioning

Currently, the Omar Dengo Foundation continues to provide guidance and technical assistance to schools, and implements three educational models within the national policy of digital education (PRONIE):

- *Educational Informatics Labs (LIE):* In this educational model, students receive programming and computational thinking lessons taught by an Educational Informatics teacher.
- *Mobile Learning with Technologies (ATM)*: In this educational model, educational schools are provided with computers and other digital tools that can be used by students and teachers to support the curriculum's learning.
- *Entrepreneurship and Innovation (EyI)*: This educational model is developed mainly within secondary technical education schools and provides lessons to develop student'' entrepreneurial and employability skills.

Advantages and Challenges of the support organisation

Policy/organisational structure	Advantages	Challenges
Omar Dengo Foundation.	Clear government mandate; Administrative flexibility and efficiency; Specialised focus: research on trends in ICT in education.	Organisational risks in every change of leadership in government; Priorities and budget to be constantly renegotiated.

Case 6. Ireland: Oide Technology in Education < PDST Technology in Education < Professional Development Service for Teachers (PDST) < National Centre for Technology in Education (NCTE)

Context and date of creation

Oide (https://oide.ie/) (formerly the Professional Development Service for Teachers (PDST)) is a publicly funded organisation that offers comprehensive support services and professional learning opportunities to teachers and school leaders in a range of pedagogical, curricular, and educational areas. Oide was established in September 2023, bringing together PDST and other teacher and school leader agencies (Centre for School Leadership (CSL), Junior Cycle for Teachers (JCT) and the National Induction Programme for Teachers (NIPT)).

PDST was established in September 2010 as a generic, integrated, and cross-sectoral support service for schools. In 2012 PDST created a special unit called PDST Technology in Education dedicated to digital education. This unit incorporated the services of the former National Centre for Technology in Education (NCTE), an agency that had been established in 1998 by the government of Ireland to facilitate the development, funding, and use of information and communications technologies in education. NCTE was responsible for the implementation of the IT 2000 initiative and was responsible for coordinating the work of ten regional Education Centres that provided support directly to local schools. NCTE was discontinued in 2012 and all its activities were transferred to PDST Technology in Education, which states that its main role is to promote and support the integration of technology in teaching and learning. Oide Technology in Education continues with the same mission and "promotes and supports the embedding of digital technology in teaching, learning, and assessment".

Main functions

Oide Technology in Education is the main support organisation for the implementation of the Ireland Department of Education Digital Strategy for Schools 2021-2027, particularly in activities related to teachers' professional development and infrastructure. Additionally, Oide is responsible for:

- Providing advice and developing policy proposals for the Department of Education on issues related to digital education.
- Management of the Department of Education's portal for schools (Scoilnet) https://www.scoilnet.ie/.
- Implementation of a safer Internet programme (Webwise) https://www.webwise.ie/ which offers information, advice, and digital resources for teachers, parents, and students.
- Planning tools for schools to plan and implement digital learning and to use formative assessments and students' digital portfolios.
- Guidance and support for schools on suitable Digital Technology Infrastructure (DTI), including computing devices, connectivity, learning platforms, cybersecurity, and technical support.
- Oide is the single point of contact and support for the 'Schools Broadband' national programme.

Changes-Transitions

The National Centre for Technology in Education (NCTE) was created in 1998 by the Irish government to implement the IT 2000 digital education policy which aimed at providing classrooms with digital resources and infrastructure, and to promote teacher skills development and support. NCTE was responsible for organising a national partnership involving schools, parents, local communities, and third-level institutions together with public and private sector organisations to meet the project's ambitious aims. The plan stated the need for effective co-ordination and created an organisational structure formed by an Educational ICT Co-ordination Unit in the Department of Education and Science, a National Centre for Technology in Education (NCTE) at Dublin City University, and a regional IT 2000 base in 10 Education Centres. The plan was very specific about NCTE's organisational structure stating that the initial staff should "include educationists (mainly seconded teachers), experienced IT staff and administrators" (Ministry for Education and Science of Ireland, 1998[35]).

In 2010 as part of a large movement of restructuring and merger of stand-alone services to schools, the Department of Education and Skills created the Professional Development Service for Teachers (PDST) with the responsibility of providing support and guidance to the Irish educational system in six areas: curriculum and pedagogy; learning and teaching methodologies; school improvement and school self-evaluation; school leadership; pupil/student and teacher welfare *and* Information and Communications Technology.

In 2012, realising the broad spectrum of activities under the area of ICT in education PSDT created a specialised unit called PSDT-Technology in Education which is also based at the Dublin City University.

In 2023, Oide was created by merging different Irish agencies to provide a fully comprehensive Professional Development Service for Teachers. Oide-Technology in Education replaced PDST-Technology in Education with the same mandate and resources.

Current functioning

Oide Technology in Education (TiE) is the main support organisation for the implementation of Ireland's Department of Education Digital Strategy for Schools 2021-2027, particularly in activities related to teacher professional development and infrastructure. According to the policy document, all Oide (formerly PDST) professional learning courses and supports should be designed to build digital competence and effectively embed digital technologies in teaching, learning, and assessment. The Oide dedicated Technology in Education Team (Oide TiE) and a team of digital technology advisers will continue to develop and facilitate flexible differentiated models of Teachers' Professional Training.

Advantages and challenges of the support organisation

Policy/organisational structure	Advantages	Challenges
NCTE-National Centre for Technology in Education.	Mandate to coordinate a large multi-stakeholder partnership; Part of a comprehensive organisational structure.	Lack of clear definition of responsibilities among the organisations.
PDST-Professional Development Services for Teachers.	Integration of ICT into other support and guidance services to schools.	Lack of focus and specific expertise on ICT in education.
Oide and PDST Technology In Education (TiE).	Specific focus without losing the possibility of integration with other educational areas.	Limited autonomy.

Case 7: Uruguay: CEIBAL < Plan CEIBAL

Context and date of creation

Plan CEIBAL (https://ceibal.edu.uy/) (CEIBAL, 2006[36]) was launched in 2006 by Uruguay's president as a project to include all citizens in the digital age. The project's original focus was on digital inclusion and equality in the access of technology. The pilot Phase of the project was implemented in 2007 with a partnership with the One Laptop per Child (OLPC) programme promoted by the Massachusetts Institute of Technology (MIT). The project had an oversight board which included the president of the country, the national university and other relevant technology and education stakeholders. Operational issues were under the responsibility of two main institutions: the Technological Laboratory of Uruguay (LATU) and the National Agency of Public Education (ANEP).

As the project evolved, LATU created a new organisation with autonomous governance and budget to implement the CEIBAL project.

Main functions

CEIBAL's activities cover 6 different areas:

- Technologies for education: devices and connectivity
- Educational platforms: ecosystem of platforms that provide quality content in mathematics, language, programming and computer science.
- Educational programmes: innovation in STEAM
- Teachers' professional development: courses and continuous learning on digital competences, life skills, innovation and new pedagogies.
- Digital citizenship
- Strategic information: education data management

Changes-Transitions

The presentation of CEIBAL's work can be organised in four different phases:

- Phase 1 (2007-2010): Delivery of devices to students and teachers, internet connection for schools, installation of video conferencing equipment in schools.
- Phase 2 (2010-2013): Development and acquisition of educational platforms and teachers' professional development.
- Phase 3 (2013-2020): Focus on the development of new pedagogical models using technology for learning.
- Phase 4 (2020-): Focus on exploring new hybrid and blended teaching formats based on available infrastructure and search for new forms of partnerships with the educational system.

Current functioning

Uruguay is one of the few countries in the world where all students in public schools receive a computer with free Internet access that, after the initial delivery, is replaced twice during their educational journey (CEIBAL, 2022). The work of CEIBAL evolved from being focused on the deployment of digital infrastructure to become a centre of innovation for education, not only in Uruguay but for other Latin American countries. The focus on innovative pedagogical methodologies and teachers' training created some overlap with the work of the National Agency for Public Education (ANEP) which is responsible for all the support services to schools. Both agencies have technical and administrative autonomy but are linked to the Ministry of Education. CEIBAL continues to expand its activities and has currently more than 500 employees.

Advantages and challenges of the support organisation

Policy/organisational structure	Advantages	Challenges
Plan CEIBAL	Strong leadership (direct involvement of country's president)	Lack of institutional basis
CEIBAL	Integration of different areas of expertise needed for the implementation of digital education within one organisation	Overlap (and potential competition) with other educational organisations with related mandates

Part III Guidelines

16 Opportunities, guidelines and guardrails for effective and equitable use of AI in education

This discussion paper was jointly developed by the OECD Secretariat and Education International, initially as an input to the discussions of the International Summit of the Teaching Profession 2023. The use of AI and digital technology as part of teaching and learning is thus the focus of the text. The text was then refined through country, expert and stakeholder consultations. It aims to facilitate collaboration between education authorities and the teaching profession and provide a starting point or inspiration for further discussions and guidelines on these issues.

Introduction

These opportunities, guidelines and guardrails for effective and equitable use of AI in education (Guidelines) represent positions on the development and use of Artificial Intelligence (AI) and digital education developed by the OECD Secretariat and Education International. The Guidelines aim to help educational jurisdictions and organisations representing teachers and educators alike in navigating what are fast moving developments in AI. A first version was given to education ministers and teacher union leaders at the International Summit of the Teaching Profession 2023. The Guidelines build on the OECD Council Recommendations on Artificial Intelligence (2019) and on Broadband Connectivity (2021). They also build on the ten principles on *Effective and Equitable Educational Recovery* (2021) developed by the OECD Secretariat and Education International in 2021.

One of the legacies of the COVID-19 pandemic is the increased use of and attention given to digital technology in education. Most school systems have used remote online teaching and learning at some point during the health crisis, and teachers, learners and families have realised the potential of digital technology for teaching and learning, as well as its limitations. The massive shift to digital learning has also exposed persistent inequalities in access to technology and connectivity as well as the crucial role of schools as social in-person places contributing to learning but also the wellbeing of students.

The irruption of digital technology continued in 2022-23 with the sudden visibility of generative AI applications (for example based on large language models such as ChatGPT or SAGE). These advances have made the power of AI visible to the public and raise fundamental questions about tasks and skills where the activity of humans and machine complement and/or substitute for each other. How does AI enhance human capacity? Does it lead to cognitive off-loading where AI performs or even outperforms at existing human skills level? Does it lead to human skill attrition when this off-loading occurs and these skills get less exercised? For educators, AI challenges a number of educational activities such as traditional models of homework assignments and assessment. This general-purpose technology has the potential to lead to another “industrial revolution” and will not leave education models untouched.

Both sets of experiences have pointed to the growing importance of the digital transformation of education (as well as in our societies) and cast light on the opportunities and challenges of embedding digital technology in education – and dealing with general purpose digital technology such as generative AI, which can be disruptive for teaching staff.

Opportunities of AI and digital technology

The use of digital technologies in education holds significant promise. When applied to education, technologies such as artificial intelligence, machine learning and robots, have the potential to improve the quality and equity of learning, free teachers’ time to focus on their teaching and provide students with new routes to learning. These educational objectives may become a reality with the support of technology, provided that teachers and learners are given the right conditions to use such technologies.

First, AI-powered adaptive learning tools can help track learners’ progress and pinpoint where learners need help and where they excel. They may support teachers in providing greater personalised teaching and learning in the classroom and allow learners to work with more autonomy and engagement under the supervision of their teachers. Some may help students remaining engaged in their learning. Social robots may support teachers and other educators as tutors, peers or instructors. Classroom analytics that provide feedback to teachers in real time about the management of their class or give them feedback about their teaching after class may also help them to improve their teaching and their students’ learning. Simulators, virtual and augmented reality may allow learners, especially those in vocational education and training programmes, to develop practice-oriented skills in a safe environment which mimics the workplace.

Second, AI-enabled technologies can support inclusive education and equity. AI-based accessibility tools using techniques such as speech-to-text and auto-captioning can serve visually- or hearing-impaired learners to better participate in classroom activities. Other learning difficulties such as dyslexia, dyscalculia, dysgraphia could also be detected sooner and addressed with a mix of technology and human interventions. A number of countries have made (or are in the process of making) such applications available to schools and higher education institutions to support students with special or specific needs. In countries with advanced information systems, early warning systems powered by AI could help identify students at risk of dropping out, who often come from disadvantaged backgrounds, and support teachers and administrators in designing appropriate interventions. Where students have access to the Internet and devices, technology may have the potential to make learning resources and knowledge accessible to broader audiences, including in lower income countries, and to help develop social and collaborative skills among students and teachers.

The effective use of AI tools in education depends on having trained and qualified teachers, who have the confidence and the autonomy to choose both the digital tools and how they are applied in the classroom. Some technology applications are currently designed to support the teaching profession. If implemented effectively, they may allow teachers to personalise their teaching, to receive feedback on it, but also to delegate or make some of their administrative tasks less time consuming. They may also help to remove burdensome tasks and free up teachers' time for instructional design and activities.

Besides serving individual learners and educators, technology can help build communities of learners and make learning more collaborative, providing new means to enhance goal orientation, motivation, persistence, and the development of effective learning strategies. Similarly, technology can build communities in which educators share and enrich educational resources and practices and collaborate on professional growth and the institutionalisation of professional practice. It can also help system leaders and governments develop and share best practice around curriculum design, policy, and pedagogy, and allows doing certain types of research at an unprecedented pace.

Generative AI applications (such as large language models) present both opportunities, unknowns and risks. They can support teachers in generating draft lesson plans and providing opportunities to develop their students' critical thinking in the classroom. These applications can support a shift in pedagogical models from having students learn answers towards supporting them in asking the right questions, navigating ambiguity and competing claims, and distinguishing fact from opinion. As the technology continues to develop, it may not only become a powerful learning tool for students and a convenient aide for teachers, but also contribute to the enrichment of dedicated technology solutions such as adaptive learning systems or customised AI answers to students' questions based on their learning journey. All this is dependent on teachers and learners having the capacity to review and adjust what AI creates.

Risks of AI and digital technology

There are also risks to the use of digital technologies in education. One risk is that inequalities can result from unequal access to technology or from stronger effectiveness of those tools for advantaged students; weaker usage by students and educators intimidated by technology; disparities in the capacity of educators and learners to make full use of their potential; and challenges to assure the quality of digital resources.

Concerns also include the privacy, security and use of learners' and teachers' personal information and data as well as excessive time spent on technology-based activities, especially for young children. The use of algorithms to make automated decisions on learning interventions (e.g., identify potential early school leavers), progression or admission could, as with similar human decisions, entail risks of bias of developers, society and past datasets *vis-à-vis* certain student groups, resulting in different forms of discrimination and perhaps amplifying and making them systematic compared to their occurrence in traditional, fully human-driven education. Another challenge is that the identification of these risks could lead to unethical human behaviour, for example expelling students at risk of dropping out or stigmatising students with special needs rather than supporting them.

The effectiveness of many AI-enabled tools and whether they contribute to improving learning outcomes or decreasing educators' workload is not always well established. AI-enabled tools may be more suitable for some subjects, given that not all forms of knowledge or processes of learning are easily transferable to a digital format. This could lead to a prioritisation of forms of learning that are easily digitised, jeopardising the breadth of the curriculum and the quality of education. The increased use of technology could also lead to the atrophy of human skills and agency and an increased dependency on the availability of AI and other technology, including for skills that are essential for success and well-being. This is particularly the case for generative AI, which entails some other risks such as the reliability and traceability of information, the risk of cultural bias, and raises new challenges for traditional assessments.

The pandemic has highlighted the importance of the teacher/pupil relationships and the social dimension of schooling. Too much time spent on technology can lead to the social isolation of students (and adults), which can have a negative impact on mental health as well as learning outcomes, especially for younger learners. In some cases, AI-enabled tools could add to the workload of teachers rather than an aide, especially when tools are not designed for and in collaboration with the teaching profession.

There are also new risks for teachers in terms of access to technology, wellbeing, professional development opportunities, as well as regarding the use of teacher data. One of the risks lies in an unethical use of the data collected about teachers' performance in the classroom.

Addressing these risks requires a coordinated effort across all education levels and all policy areas, from investing in digital infrastructure and equipment for education institutions, learners and teachers to developing sound regulations addressing issues such as data protection and privacy, cyber security, educators' digital competences, curricula with a meaningful integration of digital technologies, and quality assurance.

As with many new technologies, the rise of AI and other technologies highlights the importance of using and developing them in an ethical way, based on human and labour rights. This is particularly important for education where the development of cognitive, social and emotional skills is vital for a whole child education.

The guidelines proposed below aim to support governments, teacher unions, teachers and other educators to engage in a constructive dialogue to harness the opportunities offered by AI and other advanced technology and mitigate its risks for educational goals that are shared by the education community: equity, quality and efficiency.

1. Equitable access to affordable, high quality connectivity. Educational jurisdictions should create digital learning infrastructures at a system level that are accessible to all learners and educators in and outside of school. This strategic physical infrastructure should allow for a quick and equitable shift to remote learning if necessary.

The pandemic exposed existing inequalities in the quality access to the Internet and digital devices, including in the most affluent countries and jurisdictions. Good quality connectivity and access to the Internet is a pre-requisite to the equitable widespread use of advanced technology for learning, and governments should ensure that a comprehensive and reliable physical infrastructure is available to all schools and learners, both at home and at school. This will contribute to equity in availability, quality, and affordability of devices and connectivity.

Digital transformation can exacerbate existing inequity if access to the Internet and thus learning tools and resources are unevenly distributed among learners. Some solutions that were explored during the pandemic could be continued, such as providing specific educational websites or learning resources at zero cost when accessed through mobile Internet or the lending of equipment to families who need it. This is particularly important to preparation for another crisis, whatever its nature, which could lead to the return of remote education – or for evolving the current schooling model.

At the same time, the uneven distribution of connectivity or equipment should not, in itself, be a reason not to reap the benefits of technology where possible. As it was the case during the health crisis, innovative solutions can be designed to make digital technology accessible to a majority of teachers and learners, including developing tools and platforms that can work with intermittent access to the Internet or with unstable or low connectivity. While providing access to effective connectivity for all members of the population is becoming a high priority responsibility for governments, AI-enabled tools can still be used where this is not yet a reality.

2. Equitable access to and equitable use of digital learning resources. Educational jurisdictions should make available a set of quality digital learning resources to teachers and students, accessible in school and at home. Teachers should be able to use them at their professional discretion within the context of school and jurisdiction policies. Jurisdictions should provide guidance about usage expectations, in consultation with teachers and other education stakeholders, so that all learners, including educators, can have adequate opportunities to develop their digital skills. This soft infrastructure made up of digital learning resources and tools could provide the positive conditions for a quick and equitable shift to remote learning if necessary.

Beyond connectivity and devices, governments should ensure that teachers and learners have access to high quality digital learning resources to support their teaching and learning in and out of class. Making digital learning platforms and resources easily usable on mobile devices may enhance access and use. The pandemic has led many countries to expand their platforms of digital learning resources or to expand their licenses with education publishers. There should be strong emphasis on user-friendly access to digital resources and the provision of a variety of resources that allow teachers to select those that correspond to their teaching preferences (and learners to their learning preferences).

In the case of learners, the provision of adaptive learning systems that can be used in school or at home should be considered, as this provides a means to possibly alleviate loss of learning opportunities at home. As examples and evidence accumulates that specific digital solutions can support learners with special and specific needs, those should be mainstreamed across all digital learning resources platforms.

In the case of teachers, short videos, simulations or other materials that can easily be integrated in lesson plans and learning scenarios could be made available. Other digital tools that could help them design their lessons or generate easily learning materials and examples should also be considered.

For learning resources that are (still) relatively expensive, for example augmented or virtual reality tools, mutualising their use across schools could be an option.

In addition to learning resources, digital tools that support teachers in their administrative tasks could free them to design their lessons, to teach, and support students in their academic learning and socio-emotional development.

While equity in the access of decent quality learning resources must be a key objective, variations and inequity can come from a variety of use across classrooms and schools. While respecting teachers' pedagogical autonomy, jurisdictions should provide clear guidance about the types of digital competences learners should develop, and how. Typically, it should be across all subjects rather than by solely requiring a separate focus on "technology" or "computer science" as a subject. Curricula and other forms of guidance for teachers could be reviewed and designed, in partnership with teachers and their representative organisations. Providing training on the use of generative AI may become an important step to avoid new equity gaps based on differing abilities or confidence to use such applications.

3. Teacher agency and professional learning. The critical and pedagogical uses of up-to-date digital learning resources should become an integral part of teachers, school principals' and other educators' professional competences, fostered in initial education but also within continuous professional learning opportunities and professional collaboration. Recognising the importance of teacher agency, efficacy and leadership is key for allowing them to make a critical use of digital learning resources and design rich learning scenarios with their students.

The rapid pace of development of AI-enabled technologies raises new challenges for all professionals, and this is also true for teachers and other education practitioners. Jurisdictions should recognise that the effective use of AI in education depends on a trained and qualified workforce, which is trusted and supported to apply AI-enabled tools as and when it augments their teaching and enhances the relational and social experience of learning.

While most initial teacher education programmes include some introduction to digital tools for learning, the use of and critical engagement with digital resources in teaching should be mainstreamed in all subjects in initial teacher education programmes, so that student teachers feel at ease with the use of digital tools in the learning scenarios they offer their future students. Teachers' AI literacy should be cultivated, so they understand AI techniques, can critically assess AI productions and recommendations, and creatively use AI in their teaching.

While initial education is important, learning on the job is what makes a good teacher a great one, and continuous professional learning for teachers should include the use of technology in teaching and learning. Sustained, relevant, accessible and timely training options should be offered to teachers, but some other solutions could also be explored. Teachers who focus on developing advanced digital skills, such as “teacher coaches” or “technology champions” within schools or at the regional level, represent an approach that seems to have been efficient in different jurisdictions. At the school level, such teachers can support their peers interested in expanding their use of technology in their teaching, either within specific schools (or a school network/group). It is important to ensure opportunities for professional collaboration and peer learning as well as mentoring schemes. At the regional level, some expert teachers could also curate and disseminate ideas about the effective use of technology in education to their peers. Working conditions need to be fostered whereby teachers are enabled to establish professional learning networks and teacher leadership across schools to evaluate the quality of AI applications and contribute advice on what applications should be useful for teachers in the future Ultimately teachers should have the pedagogical space to make choices around EdTech in the classroom.

Consistent, high-quality professional learning and development is vital for all teachers if they are going to be able to use information and communication technology confidently and effectively. Teachers should be able to decide on the form of professional learning they receive. Many teacher unions provide such professional learning opportunities and those that do not should be supported to do so.

The greatest risks of technology may come from an uncritical use of digital resources. Teachers need the time, professional development and working conditions to be able to design and combine digital resources to use in and out of class. While they do not need to become data scientists, they must be at ease with quantitative information and dashboards – as well as other forms of information generated by AI and other technology. Conversely, dashboards and information provided by digital technology should become more teacher- and user-friendly.

Digital technology is a powerful tool itself to support collaboration and peer learning among teachers, thanks to public (and private) dedicated platforms. Jurisdictions should provide such open source and teacher-curated platforms and enable teachers, within the school day, to share materials, ideas, comments on other existing ones across schools. Teacher contributions should receive some form of recognition. Indeed, learning through professional learning communities is usually the most effective for teachers and other professionals.

4. Student and teacher wellbeing. The use and development of AI-enabled technology should put learners’ and teachers’ wellbeing and mental health to the forefront, including by keeping a good balance between digital and non-digital activities. Ethical guidelines on digital communications which recognise that learning is a relational and social experience involving human to human interactions should be created in partnership with teachers and their organisations.

While digital technology has the potential to improve teaching and learning, for example by diversifying learning scenarios for students or by making education more aligned with contemporary society, the excessive usage of digital technology and expanded possibilities of diffusion of unethical content present risks for the wellbeing of learners and teachers. The pandemic has highlighted the fact that education is a relational activity. Indeed, studies show that a large majority of students and teachers prefer in-person teaching and learning and appreciate the social and emotional interactions offered by in-presence schooling.

Beyond a certain point, the use of digital devices correlates with lower learning outcomes. Despite the lack of conclusive evidence on this correlation, it is reasonable to limit time on digital technology, not the least to ensure that future generations can still enjoy activities that have been valued by human beings for centuries and which will help them value and continue human heritage and culture into the far future. While the exposure to technology has become a part of current society that education systems cannot ignore, learning activities that do not involve digital technology should remain an important part of children's development and students' formal education. Calibrating the right approach and technology use to the right learners will be key. Teachers should not be expected to be constantly in front of their computer screens analysing data or responding to management or parental requests.

Yet digital technology also has the potential to support students' and teachers' wellbeing, for example by diagnosing at-risk students or teachers who may require emotional or clinical support, in tandem with robust teacher and student wellbeing policies and programmes. Specific tools could be designed which help detect bullying (and cyberbullying). AI may also help address student well-being through data analytics connected to digital tools and human services related to socio-emotional learning. This could help give feedback to teachers about how they respond to students' socio-emotional needs both in and outside the class. More generally, ensuring safe and conducive learning environments requires a pro-active approach to AI literacy for both teachers and students, making the understanding of its evolving strengths and limitations a fundamental part of modern education.

5. Co-creation of AI-enabled digital learning tools. Jurisdictions should encourage the involvement of teachers, students and other end users as co-designers in the research and development process of technology to help ensure the usefulness and use of AI-enabled digital tools. An innovation-friendly ecosystem that makes innovation and continuous improvement a culture should allow technology developers to experiment and pilot some tools with the support of teachers and learners.

Technology can sometimes be "in advance" of what stakeholders find appropriate, and sometimes "irrelevant". Citizens should have a say in the use of solutions designed to support them.

While some technology companies have emerged which focus on education, most past solutions deployed in education have been just derivatives of applications that had been developed for other sectors of society. Some general-purpose tools such as generative AI show that they can be extremely powerful despite not necessarily being "educational" in purpose.

Education technology companies have technology competences that many teachers typically do not have. This is why a constructive dialogue with them is necessary and desirable. For education technology companies to develop "useful" tools for teachers, teachers need to be involved in the design process, piloting and monitoring and evaluation of these tools. Pedagogically sound and culturally relevant tools can be ensured through such a co-design with the teaching profession. This may require building further capacity within the teaching profession. As this may increase the use of those tools, this would also be aligned with developers' economic incentives. Teachers also need to feel that they are protected from being used for testing inappropriate products, and jurisdictions should elaborate some clear rules in that respect.

Government-funded institutional programmes could involve government, university researchers, industry, teachers and other education stakeholders in defining which types of tools should be prioritised and in researching their effective use within schools. Some governments have already developed such programmes. This practice-engaged research and development programmes should go beyond the functionality of technology to analyse how technology is used in context and its impact on both equity and quality. They should also work on the social and legal adjustments that would be required for the widespread adoption of the solution they propose. This "co-creation" principle should be a principle even when it is challenging to involve end users, for example, students with special needs.

One important, positive side effect of these programmes would be to help understand and shape the social context in which AI-enabled education technologies would best be used (the classroom, home, etc.), and facilitate social negotiation and acceptance of these tools by the teaching profession and society.

6. Research and co-creation of evidence through disciplined innovation. Jurisdictions should foster research about the effective use of digital tools in education, including practice-engaged research projects that allow teachers to innovate in their classrooms, co-design the uses of technology with researchers that evaluate and document the conditions under which technology use works and for whom. Researcher-led projects can cast light on the most effective uses of AI-enabled technology. In principle, digital transformation enables quicker feedback and improvement loops than in the past, which education systems should benefit from through an active focus on research.

The pandemic has shown that education systems can be innovative when needed and has also shown how much teachers and school leaders are able to develop their own "micro-innovations". Beyond decisions related to the expected use of digital tools in the classroom, educational jurisdictions should work to establish opportunities for teachers to co-design new pedagogically sound and culturally relevant classroom tools. Teacher unions could contribute to that process.

Co-creation is essential for education systems to have useful digital tools for teaching and learning, but teachers can also contribute to the generation of research evidence by collaborating with researchers about its effective uses. Innovation can only take place in a climate which is dominated by trust that those innovating will be able to learn from any failure without receiving a punitive response, and failure and risk taking should be tolerated within reasonable expectations. Teachers should thus be able to propose research evaluation of their practices or ideas.

Research projects about uses that are envisioned and developed by university researchers are also valuable and should also be encouraged. Jurisdictions should support researchers to carry out such research and share the findings of research projects involving teachers to evaluate how digital technology can effectively be integrated in their teaching and benefit their students' learning and socio-emotional development. Education jurisdictions should thus encourage and make it possible for teachers to be part of research projects making these uses more visible to the teaching profession. In most cases, the focus of the research should not be technology in itself, but the use of technology and how it benefits learners or teachers and in what conditions.

The use of digital platforms can allow for research designs that generate much quicker results and improved solutions than past “analogic” methods. This type of research should be encouraged, under the condition that its results are publicly shared for the benefit of the whole education community.

Research into the safety, efficacy, and equity implications of AI-enabled tools in education should be emphasised, for example on their impact on cognition and child development.

7. Ethics, safety and data protection. Data protection policies should ensure that the collection of data contributes to securing effectiveness and equity in education while protecting students’ and teachers’ privacy. Educational jurisdictions should provide schools and teachers with clear guidance about data protection and possibly pre-negotiated contracts or guidelines when they resort to commercial solutions. They should ensure that safety or possible algorithmic bias are tested and addressed in their policies. Clear ethical guidelines should also be developed. The ethical use of data about teachers should be negotiated with teachers and their representatives as part of bargaining agreements.

The use of AI-enabled technology raises new concerns about data protection and privacy. Many jurisdictions have strong data protection regulation in place, which apply to education and the access to student and teacher data. Some have specific education data protection policies. In particular, the access to administrative data tends to be strongly regulated. Data protection implies strong underlying cybersecurity. The rise of generative AI also raises new forms of data protection issues where “children data” are not protected by law from reuse and resale. Where not already the case, data protection policies should also extend to biometric data.

Jurisdictions should also consider regulations and policies related to the safety, effectiveness, and possible bias of digital tools before they are introduced in education systems. New classes of concerns beyond data protection, privacy or safety have appeared with AI-enabled digital tools as they allow for stronger pattern recognition and greater automation than other technologies. This implies that policies should go beyond privacy and safety and include some institutional mechanisms to monitor the effects of using AI and other digital tools on equity and quality in education.

Privacy and data protection must be balanced against other important educational objectives such as equity or effectiveness, which may require the collection of personal data, including sensitive data. For example, while it is preferable to avoid demographic characteristics as key parameters in AI algorithms, when possible, the possibility to identify and address algorithmic bias and thus improve fairness depends on the collection of personal data. Algorithmic bias is one of the new risks related to the emergence of AI in education, as some groups may be discriminated against based on past data, the training model of the algorithm or just work better for some groups than others: countries should ensure that new digital tools are tested to avoid possible biases. Even in the absence of biases, as AI effectiveness is largely based on detecting "profiles", the risk of human stigmatisation of students (or teachers) in different categories should be addressed. There is a general need for monitoring and evaluation of the effectiveness of digital tools on a variety of dimensions.

In many instances, when it comes to the use of digital tools in school, school boards, school principals or even teachers are left with the responsibility of interpreting or implementing regulations regarding personal data protection and other policies with limited guidance, for example when contracting some digital tools. Jurisdictions should provide guidance and support to school principals and teachers to implement these rules in a way that does not place additional burdens on teachers.

The regulatory and ethical use of teacher data by their employers should be defined and negotiated with teacher unions and other relevant stakeholders. As a matter of principle, an ethical use of data collected about teachers should support the quality, effectiveness and fairness of their teaching and the learning of their students, regardless of their personal characteristics.

8. Transparency, explainability and negotiation. When using digital tools based on advanced technology that are high stakes for students, teachers, or educational establishments, such as digital forms of evaluation and assessment, educational jurisdictions should be transparent about the objectives and processes by which algorithms reach their recommendations. The uses of high stakes digital tools must be discussed and negotiated with all educational stakeholders.

One challenge of AI-enabled technologies is that most people do not understand how they work and what can be expected of them. Generative AI is a striking example as it is currently difficult to fully explain the details of how it operates.

Transparency is essential for uses of education technology, particularly in cases that are high stakes (if and when they happen) – as well as the verification of the accuracy of their performance for all sub-groups of the target populations in education. Explaining how they work to teachers, students and families is important, and information, education and training about them should be provided. At the very least, explaining the criteria or factors which they take into account when describing their objectives and functioning is essential. Policy makers should balance the expected effectiveness of tools against their explainability or transparency.

In any event, jurisdictions should always be transparent about the objectives, functioning and possible limitations of the digital tools they (or their schools) use, notably when they have high stakes for individuals. It should be standard practice that there is constant, constructive dialogue between jurisdictions, teacher unions and other stakeholders about the introduction of broad-impact digital tools. This matches democratic values while making their trustworthy use easier.

9. Human support and human alternatives. As AI-enabled digital tools will allow for increased automation of parts of educational processes, from administration through to teaching and learning, jurisdictions should ensure that learners, teachers, and other education stakeholders, can receive timely human support when they face a problem, and, when appropriate, a human alternative to the AI-enabled tool.

As the use grows of AI-enabled tools by administrators, learners, teachers and other educators, decision processes based on AI diagnosis and suggestion may be relied on more and more by human beings as the default position. In some cases, automated processes could make it more difficult to ask questions and receive a better understanding of the rationales of decisions that affect education stakeholders. In this context, it is important for jurisdictions (or other relevant bodies) to be able to provide human help in a timely manner when education stakeholders have a problem, for example when they believe that the automated process has led to a mistake (for example in the case of an assessment or an admission process), or when they would need advice about how the system will use the information they input (for example in a school application process). AI tools are more trustworthy if they are framed with the "human -in-the-loop" idea.

It is not always possible or desirable to allow people to "opt out" of the use of digital tools. For example, the use of data in contributing to the improvement of education, particularly of disadvantaged groups, relies on a comprehensive participation in data gathering. It is also not practical for families to individually opt out of digital solutions chosen by educational institutions to support their children's learning. This does not mean that human alternatives should not continue to be considered. For example, evaluations that are high stakes for learners or teachers require a human alternative. While the pandemic showed that AI-enabled remote proctoring can help students take exams or tests remotely when in-presence exams were very difficult to offer, their continued use should include an alternative human proctoring option given that students from different households have very different levels of connectivity, living space and examination conditions when at home. Jurisdictions should thus consider whether human alternatives to AI-enabled technology should be provided, when appropriate.

OECD Digital Education Outlook 2023

TOWARDS AN EFFECTIVE DIGITAL EDUCATION ECOSYSTEM

The *Digital Education Outlook 2023* provides a comparative, thematic analysis of how countries shape or could shape their digital ecosystem. Student information systems (or Education Management Information System - EMIS), learning management systems, digital assessment platforms, study and careers guidance: what are the different components of countries' digital education ecosystem? How and to what extent do countries leverage teachers' digital competences and the latest opportunities offered by artificial intelligence (AI)? How can countries make the most of their digital ecosystem so that it is trustworthy, useful, effective, and equitable? How do and can countries allow for digital education to continue to improve and innovate education? Based on numerous country examples coming from an OECD survey on countries' digital education infrastructure and governance and from desk research, the report shows where countries stand and where they could be going from there to benefit from the digital transformation. It also points to opportunities, guidelines and guardrails about the effective and equitable use of AI in education.

The report covers most OECD countries and a few partner countries. It will be of interest to policy makers, academics and all education stakeholders interested in the digital transformation of education systems. *Country Digital Education Ecosystems and Governance: A Companion to Digital Education Outlook 2023* supplements this book by providing detailed and comprehensive information for each country.

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