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.

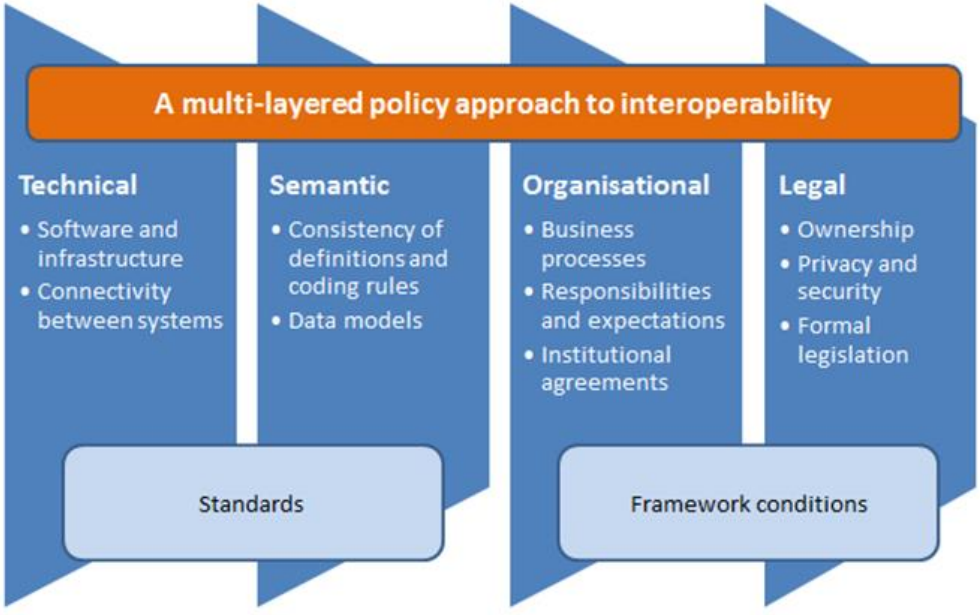
Interoperability increases the consistency and exchangeability of data collected and maintained by different systems. It reduces the need of ad-hoc processing to re-input, re-format or transform data, so that relevant information can be delivered in a more cost-effective and swift manner to support actions 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.

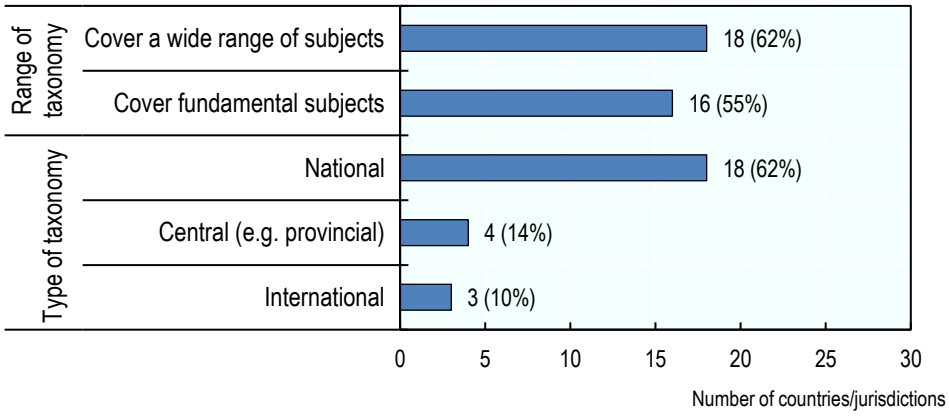
Beyond the publication or endorsement of specific (sometimes open) standards, countries could incentivise vendors to use them through procurement processes. Three out of 29 countries that participated in the OECD survey on digital infrastructure and governance include some interoperability criterion 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.

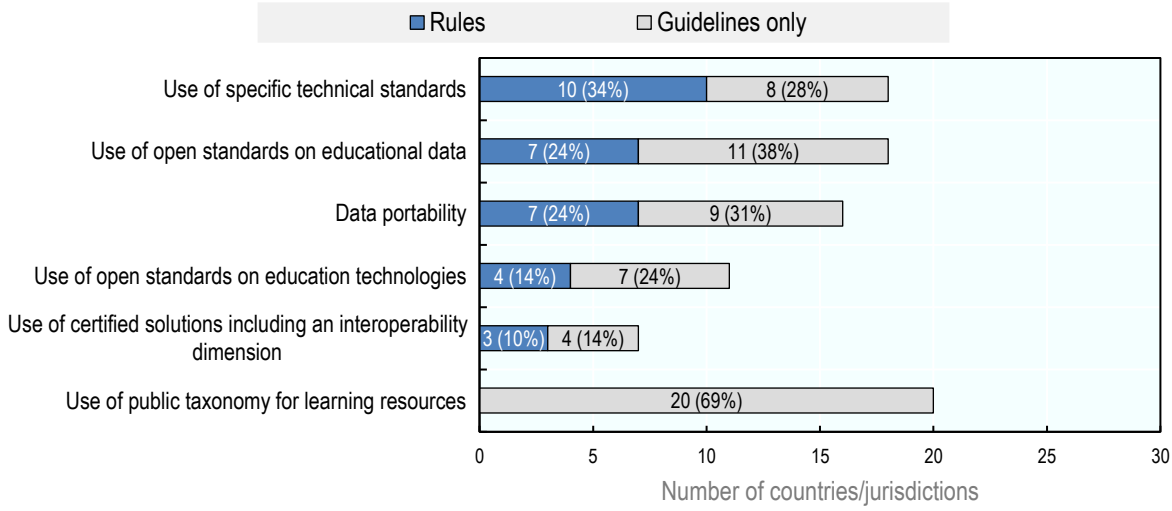
For instance, England supports DfE Sign-in, a single sign-on (SSO) service, for their two student information systems (Analyse School Performance and Get Information About Pupils) and online register for schools (Get Information About Schools). Korea also promotes the use of the single sign-on (SSO) 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.

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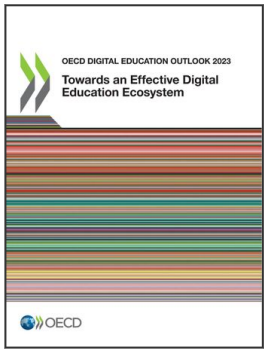

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