Department for Education

International evidence on decision making on technology

Final report

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This review identifies approaches taken by national governments to decision making in technology in schools for pupils aged 4-18 and how this is supported and delivered. A geographical mix of 14 OECD countries, identified as being active in promoting digital technology in schools (van der Vlies, 2020), were reviewed using primary sources such as government websites, strategies and submissions to organisations such as OECD and Eurydice, supplemented with information from academic literature. Information for each country was compiled in a template under the key decision areas of interest as set out by the Department for Education (DfE). These country reports are available as Appendix 1. Information from these country reports was then synthesised and analysed to look at commonalities and differences in approach between countries. The countries in the review are:

- Australia (in particular, the states of New South Wales (NSW) and South Australia (SA), both of which have developed digital strategies for education)
- Austria
- Czech Republic
- Denmark
- Estonia
- Finland
- France
- Ireland
- Italy
- Japan
- Netherlands
- Norway
- Sweden
- United States of America (USA)

Background information

While in **Australia** and the **USA**, education is primarily the responsibility of the state governments, the federal governments in both countries do take some decisions centrally. In the **Netherlands** and **Sweden**, most decision making is at school level, with funding going directly from government to schools. The majority of other countries in the review have a fairly devolved level of decision making and funding in education, often to municipal level, although municipalities may further devolve budgetary decisions to schools. However, most central governments retain responsibility for the curriculum and initial teacher education which provides them with a degree of leverage in promoting the increased use of digital technology in schools.

The majority of countries in the review have produced a digital strategy that is either school-specific, or mentions schools as part of a wider digital strategy. In a working paper published by the OECD, van der Vlies (2020) noted that education has not been at the forefront of digitalisation and that the coronavirus (COVID-19) crisis has shown that familiarity with digital tools remains limited. Schools are faced with two challenges: the first is to ensure that teaching and learning can benefit from new tools and technology; the second is to equip students with the right skills and knowledge to enable them to fully participate in increasingly digitalised societies and workplaces. Key to both these aims is that students have sufficient access to technology in schools and that their teachers feel sufficiently competent to support students' digital learning and maximise the opportunities offered by new digital learning tools. Consequently, the majority of digital strategies in this review contain objectives related to these aims.

Findings

Countrywide digital infrastructure

All of the countries in the report are supporting high-speed broadband through national plans and strategies. For a number (**Austria**, **Czech Republic**, **Denmark**, **Estonia**, **Finland**, **France**, **Ireland**, **Italy**, **Norway** and **Sweden**), a key objective is to ensure coverage extends to rural areas, providing funding where this would otherwise not be commercially viable for private providers. For countries in the EU, this is often supported with EU funding . **The Netherlands**, however, has opted for a market-based infrastructure roll-out with an emphasis on the role of local and regional authorities in coordinating and simplifying the process for providers. This will be supported through a framework, currently in development by the national government, to help local authorities apply for state aid to support construction. For

Australia and the **USA**, a major objective is affordability for low-income households, with funding directed towards supporting this.

Strategic approaches to increasing the use of digital technology in schools

Strategic approaches to increasing the use of digital technology in schools fall into three categories:

- those countries that have a specific national digital education strategy (Austria, France, Ireland, Japan, Norway, Sweden and the USA)
- those that include digital education as part of a wider national digital strategy (Italy and the Netherlands)
- and those that instead include digital education as part of their national education strategy (Czech Republic, Denmark, Estonia and Finland)

There is no overarching digital strategy for **Australia**; responsibility for public schools lies predominantly with the states and territories and just two states – New South Wales and South Australia – have produced digital strategies.

Areas covered by digital education strategies

The main areas covered by the digital education strategies are:

- teachers' digital skills (included in the strategies of 12 countries)
- new approaches to teaching and learning (12 countries)
- improved digital infrastructure in schools (10 countries)
- improved connectivity for schools (9 countries)
- changes to the curriculum (9 countries)
- and improved use of educational data (9 countries)

In addition:

- digital learning resources are included in the strategies of six countries
- students' access to hardware, data protection, school leaders' digital skills, and technical support for schools/teachers are included in five strategies
- pedagogical support/mentoring for teachers, the increased use of digital technology in school administration and stimulating and disseminating innovation are included in four strategies

- and Artificial Intelligence (AI) is mentioned by three strategies

Implementation

Denmark and **France** are the only countries in which central government has a direct role in the implementation of digital strategies. In Denmark, responsibility is divided between central government and local government (municipalities), with the former responsible for public infrastructure and IT standards, and the latter for digital infrastructure in schools, learning management systems etc. In France, central government shares the responsibilities for implementation with regional authorities and local government (*départements).* At the ministry level, the Directorate of Digital Technologies for Education (la Direction du Numérique pour l'Education (DNE)) is responsible for matters related to ICT in schools.

Funding

Specific funding is attached to digital strategies and plans in nine of the countries included in this research: **Australia** (both NSW and SA), **Austria**, **Denmark**, **Finland**, **France**, **Ireland**, **Italy**, **Japan** and, to some degree, the **Netherlands**, although the amounts and scope of the funding varies considerably. The funding is devolved to:

- schools in Australia (NSW), Ireland and Italy
- regional and local government in France and Japan
- local government in Denmark
- local government and education providers in Finland
- and a specialist government-funded digital unit in South Australia (SA)

In Austria, the funding is largely intended to develop central offers of resources, training and support. Information is not available for the Netherlands.

Four countries offer no specific funding linked to the strategies (**Norway**, **Sweden**, **USA** and **Estonia**). We were unable to establish whether funding is linked to national digital strategies and plans in the **Czech Republic**.

Other initiatives to increase the use of digital technology in schools

All countries in this research have undertaken other initiatives to increase the use of digital technologies in the school sectors. In 12 countries, the investments have been made by central government, however two countries (**Estonia** and **Finland**) have sought to attract support from industry.

The key themes of the initiatives include:

- professional development for teachers (Australia, Austria, Czech Republic and Norway)
- improving digital infrastructure (Ireland and Japan) and broadband connectivity (Ireland, Italy and the USA)
- student access to devices (Estonia, Finland and the USA)
- digital resources for students (Finland and Estonia) and teachers (Finland)
- activities for students, including computing challenges and summer schools (Australia)
- digital national tests (Sweden)
- tools to support schools to develop digital improvement plans (Estonia)
- leadership development for school principals and ICT leaders (Australia)
- and establishing links between schools and universities to accelerate ICT development (Japan)

Evaluations of cost-effectiveness

There are no studies in the Anglophone literature on the cost effectiveness of digital education strategies and plans, although in 2019 the French Court of Auditors (Cour des Comptes), which is responsible for monitoring state spending in France, did recommend that future investments in **France** should be better linked to teacher training, innovative pedagogies, new pilot projects and use of AI for education (European Commission, 2020). However, evaluations of some aspects of digital education strategies have been undertaken in the **Czech Republic**, **Denmark**, **Estonia**, **Finland**, **Italy** and (on a smaller scale) **Austria**. For the most part, these evaluations highlighted the barriers to implementation which included deficiency in resources, lack of strategic planning and gaps in teachers' digital skills.

Specific decision areas

Broadband and infrastructure

Only **France** and **Japan** have central systems in place for broadband and infrastructure in schools. In **Australia** and the **USA**, decision making is devolved to state level, although in the latter, responsibility is frequently devolved further to school districts. In **Austria**, **Denmark**, **Estonia**, **Finland**, **Norway** and **Sweden**, responsibility for infrastructure falls to the municipalities. Schools themselves have the responsibility in the **Czech Republic**, **Ireland**, **Italy** and the **Netherlands**, although school boards may be responsible for more than one school in the latter.

Hardware

Hardware (usually devices) is mentioned in the digital strategies of **New South Wales**, **South Australia**, **Austria**, **France**, **Sweden** and the **USA**. In **Italy** and **Estonia**, the approach is for students to bring their own devices (BYOD) into schools. For the other countries in the review, hardware provision is either the responsibility of the local authority or the school.

Security

Data and cyber security tend not to be a significant aspect of digital strategies relating solely to education. Most of the information on security relates to broader strategies for digital transformation, such as those for the public sector as a whole, although it is assumed that education would be a part of this.

Data and interoperability

Single sign-on solutions are available in some countries – **Austria**, **Denmark**, **Estonia**, **France**, the **Netherlands** and **Norway** - and proposed or in development in others – **Italy** and **Sweden**. Ambitions for increased interoperability and data sharing seem to have been hampered by, in the case of Japan, local privacy laws, and, in **Sweden,** by the decentralised nature of the system. In **Estonia**, the interoperability platform X-road was introduced in 2001 to allow data exchange between all decentralised databases.

Back office and management information systems

For **South Australia**, **Austria**, **Denmark**, **Estonia** and **France**, solutions enable parents and carers to interact with the education system in myriad ways to support and understand their children's education. Evidence of nationwide single business administration systems are less common, with a more frequent approach being to be facilitate the access of different information systems through a single interface.

Curriculum content

While all countries for which we have information have taken steps in recent years to strengthen the development of digital skills in their curricula, increasingly countries are doing so through embedding the use of digital technologies in other curriculum subjects instead of, or as well as, having ICT or computing as a subject in its own right.

Curriculum support and resources

In **Australia**, the government has developed an online portal specifically to build pupils' digital capability. Other countries such as **Austria**, **Czech Republic**, **Denmark**, **Estonia**, **Ireland** and **Japan** have developed online databases of resources linked to subjects across the curriculum – in some, such as **Japan**, as a response to the pandemic. While these are sometimes provided centrally by the government or its agencies, in other countries, such as **Estonia** and the **Netherlands**, these resource portals are co-created by educators and companies or, as in **Finland**, by consortia of publishers and providers.

Accessibility

Although many digital strategies make mention of the power of digital learning tools to adapt to individuals' progress and, by implication, to enhance inclusivity, surprisingly few include specific Special Educational Needs and Disabilities (SEND) related goals or initiatives.

Staff training

The majority of digital strategies make reference to the importance of digitally competent teaching staff. The initial education of teachers (ITE), in terms of the standards and frameworks that govern courses, are typically set by national government. It is clear in many countries that the digital content of these programmes has often been strengthened, though it is not always clear whether additional funding has been made available to deliver new content. However, **Norway** has made targeted funding available to ITE providers for innovative approaches. Countries are also concerned about the digital competence of serving teachers as well as those entering the profession and this has given rise to central offers such as Massive Open Online Courses (MOOC), free for teachers to join, in a number of countries. Some countries, such as **Austria**, **Denmark**, **Estonia** and **Norway**, have developed digital competency frameworks for teachers to guide both ITE and ongoing professional development.

Technical support

We were able to find very little information in the Anglophone literature relating to most forms of technical support. This may be because support staff are, in most countries, employed directly either by the school or local authority, and there are no nationally mandated standards or qualifications. However, **Austria**, **Denmark** and **Ireland** do provide guides and links to support schools in managing technology. In **Japan**, the Global and Innovation Gateway for All (GIGA) school programme has invested significant funding into supporting the placement of local governments' ICT engineers in schools to promote ICT. Several governments (**South Australia**,

Austria, **Finland**, **Italy** and **Norway**) also provide peer-to-peer support through initiatives which designate teachers as mentors for other teachers in the school, or through school-to-school support where digitally more advanced schools provide support to others at an earlier point in their journey. These schemes are likely to combine a degree of technical support with ideas for using digital resources to improve pedagogy.

Gaps and Conclusions

The availability of Anglophone sources in different areas is highly variable, with some countries providing detailed information (at least in some aspects) and other countries providing only very high-level information. This makes comparisons challenging – with the absence of published information not necessarily meaning that there is no activity in a particular area. Perhaps because of the highly decentralised nature of most education systems in this review, evaluations of digital strategies are comparatively few, and often focus on barriers to implementation. That funding is also highly devolved or embedded into other funding streams (for example, teacher training and curriculum reform) meant we were unable to cover any evaluations of cost-effectiveness.

While digital strategies varied considerably, common to most models were ambitions related to improving pupils' digital competence with, as a prerequisite of this, the need to improve teachers' digital proficiency and understanding of how technology can enhance pedagogy, and access to the necessary digital infrastructure and devices.

Introduction and methodology

Background

The Department for Education (DfE) published a digital strategy in 2019 and, following significant changes in how schools used technology during the pandemic, the department is now designing a sustainable approach to the use of technology in the education and care sectors. Both here and in other countries, COVID-19 changed priorities to the use of technology in education, and highlighted gaps in expertise and access including: schools' digital capabilities; teachers' expertise; pupils' access to technology; and familiarity with technology on the part of pupils and their families and carers.

Aim of the review

Within England, schools and colleges have the autonomy to manage their own technology estate and the technology they use. The department required a rapid evidence review to understand the approaches other countries use in making decisions about technology choices in educational establishments catering to 4–18 year-olds. Findings will be used to inform the department's future work.

Objectives

The review sought to meet the following objectives:

- Identify the strategic approaches taken by national governments with regard to funding investment in technology in schools and colleges, for pupils aged 4-18. This includes an understanding of where spending and decision making power sits in each country's delivery chain from government to individual schools.

- Develop a framework of technology decisions, assessing several different countries on where their decision making sits with a focus on 4-18-year-olds. Decisions include those around broadband; digital infrastructure (including Wi-Fi, switching and cabling, servers and cloud storage and internal networking in school/college buildings); hardware (for example, laptops, desktops, tablets, peripherals); security; data (interoperability); back-office and information systems; curriculum content; curriculum resources; accessibility (for example, screen readers); staff training; and technical support.

- Understand the extent of investment in infrastructure in other countries, and how this is supported and delivered.

- Understand the level of centralisation/devolution for different types of technology decisions and associated funding in different countries.

- Determine whether there are common models in place between different countries, and if countries can be grouped by their approach to investment in technology infrastructure for schools and colleges.

- Understand rationales for the level at which decision making and funding is delegated, the reasons behind such decisions, and whether they are consistent between different models.

- Identify if any models are externally evaluated as being more or less cost effective.

Methodology

Evidence from the following countries, which represent a geographical mix of OECD countries that have been identified as being active in promoting digital technology in schools (van der Vlies, 2020), were reviewed:

- Australia (in particular, the states of New South Wales (NSW) and South Australia (SA), both of which have developed digital strategies for education)
- Austria
- Czech Republic
- Denmark
- Estonia
- Finland
- France
- Ireland
- Italy
- Japan
- Netherlands
- Norway
- Sweden
- United States of America (USA)

Information for each of the countries included in the review was compiled in a template based on an agreed technology decisions framework to facilitate comparative analysis. The populated country templates are attached as Appendix 1.

The information for each country was drawn from primary sources (government or their agencies' websites or their submissions to, for example, OECD or Eurydice) where possible. This was supplemented with information from academic sources, although academic research in this space is not extensive; in particular, there are few studies in the Anglophone literature evaluating the impact of the increased use of digital technology and those that do exist are generally small-scale, perception studies. There is also little research to date on the cost-effectiveness of digital initiatives. A full research protocol is attached as Appendix 2.

Where figures are given for funding of initiatives, these are presented in the relevant country's currency, with conversion to GBP. Conversion figures are at mid-market rates as of February 2022.

Structure of this report

The main sections of this report compare the use of digital technology in schools in the countries under review within several themes, drawing out commonalities and differences to respond to the research questions. We also highlight particularly interesting examples from different countries in each section. The country reports in Appendix 1 provide more in-depth accounts of strategies and initiatives for each country under consideration.

Terminology

Parents – a number of countries make reference only to 'parents' in aims and objectives such as improving communication with the school. While we have reported these using the terminology of the country concerned, we assume that this also includes those such as carers and guardians with legal responsibility for children.

Digitalisation – this term is widely used in the plans and strategies of the countries in this review and the academic literature. While we have retained the term where this is in the title of a plan or strategy, or when we are quoting a source, elsewhere the term 'use of digital technology' or similar has been used. This term includes strategies and activities relating to digital infrastructure, devices, curricula, teacher training and professional development, digital competences and support and resources related to the use of digital technology.

Background information for countries in the review

This section provides an overview of the way education is structured in terms of decision making and funding in the different countries included in this review. It also identifies issues related to the use of digital technology in their schools using comparative information drawn from OECD indicators.

Overview of decision making and funding

Australia

Education in Australia is primarily the responsibility of the six states and two territories. Schools are classed as government or non-government schools. State and territory governments have been responsible for delivering school education in their jurisdiction since Australia became a federation. National education policy is decided by all governments working together through the National Cabinet. Until relatively recently, each of Australia's six states and two territories set their own curricula which could be quite different from each other. In 2008, all federal governments agreed a national curriculum was needed to deliver an equitable, quality education for all young Australians and the national curriculum was developed over a number of years. While the states and territories fund government schools, the central Australian Government, in line with its commitment to parental choice, provides funding to non-government schools taking into account the capacity of school communities to contribute to school's operating costs, for example, the ability of parents to pay school fees. Whether decisions take place at school level or state level varies according to state or territory and school status. For independent schools (including independent public schools) this will be at school level, although some schools (predominantly catholic independent schools) may be part of a cluster in which decisions may be at cluster rather than school level. There is no overarching digital strategy for Australia as responsibility for public schools lies predominantly with the states and territories, although the states of New South Wales and South Australia have developed digital strategies for education. However, the national government does provide financial support for initiatives related to digital aspects of the curriculum.

Austria

Schools have a great deal of autonomy in Austria when it comes to decision making, although the federal government does have levers at its disposal such as curriculum frameworks, pupil testing and teacher training that enable it to improve the knowledge and use of digitital technologies in schools. The 2017 Education Reform Act altered education governance, moving from regional boards of education to a single authority, the Board of Education - a joint authority of the Federation and the provinces – which allocates resources to schools predominantly based on pupil numbers. The act also allowed schools to form clusters of up to eight schools to improve pedagogy and the effective use of resources. Maintenance and infrastructure are the responsibility of the municipalities, supported by the provinces with financial grants. School heads are responsible for pedagogical matters, organisational development, staff recruiting and management, quality management and the management of resources within their allocated budget. The Austrian Government launched the Digital Schools Master Plan in 2020.

Czech Republic

Public basic schools (for ages 6 to 15) are usually established by municipalities or a group of municipalities; however, schools can also be established and run by private entities or religious organisations. Public schools obtain funds from the state budget and from the budgets of territorial administrative units (regions and municipalities). Schools can also acquire some funds through their economic activities and participation in international programmes. Budget allocations take into account fields of study, the financial cost of support measures and the number and different salary levels of teachers in individual schools. School leaders appear to play a central role in purchasing decisions. European Schoolnet (2018) reported that head teachers of basic schools and upper-secondary schools consider ICT equipment as the area where schools should invest the most. A digital strategy ran until 2020 but it is not clear if and when an updated strategy will be introduced. However, digital learning is part of a wider education strategy that runs until 2030.

Denmark

Denmark operates a highly decentralised system of schools, with a great deal of autonomy at municipal level for primary and lower secondary schools, and at school level for upper secondary and beyond. Funding, which comes either directly from the government for upper secondary or from municipalities for other types of schools, is largely allocated on the basis of pupil numbers and socioeconomic factors. There is very little in the way of funding for specific initiatives. A number of overlapping digital strategies, action plans and initiatives co-exist, with education-specific strategies largely expanding on aims outlined in wider digital strategies. Although national strategies are developed with wide stakeholder involvement, it is recognised that regional, local and school level strategies for implementation need to be created in order to adapt to local circumstances.

Estonia

While most pre-primary and general schools are owned and run by the municipalities, most vocational schools are state-owned and run. For primary and secondary education, municipalities receive a national government grant based on four earmarked components: study materials, school lunches, professional development, and teacher and school leader salaries. Local government at municipal level has primary responsibility for school placements, attendance and the staffing, finance and maintenance of schools. Municipalities decide on how to allocate funding to individual schools, and schools have a high level of autonomy over their budgets. At school level, a board of trustees submits proposals and budgets to the executive body of the municipality (in state-owned schools, a school council performs this function under the auspices of the Ministry of Education and Research). There is no single digital strategy. However, there are two education strategies that cover early learning and adult education and training, as well as schools, and which also encompass objectives relating to the use of digital technology in schools.

Finland

The school system is highly decentralised and most education-related decisions are taken at municipal or institutional level, with strong stakeholder participation to be responsive to local needs. While the state sets the national curricula and education strategies, these provide relatively loose frameworks in which local authorities and education providers can develop their own approaches. Local administration is the responsibility of local authorities, most commonly municipalities or joint municipal authorities. These make the decisions on the distribution of funding, local curricula and recruitment of personnel. The municipalities have the power to delegate decision making to schools, and teachers have pedagogical autonomy in implementing the national curriculum, including teaching methods and the choice of textbooks and other learning aids, including digital resources. The use of digital technology in Finnish schools, while ultimately the responsibility of municipalities and schools, is guided by broader strategic programmes from the government with specific projects related to schools within them.

France

Over 90% of the funding for the school education system comes from the state, the three levels of government below the national level (administrative regions, départements and communes), other public administrations (such as consular bodies, chambers of commerce and industry, and hospitals) and public and private companies. The regions fund upper secondary schools, the départements lower secondary schools and the communes fund primary schools. The state funds teaching staff and the three levels of regional/local government cover the cost of technical staff and almost all operating and investment costs. Decisions about technology choices are informed by an annual national survey of primary and secondary schools, which provide indicators on equipment, infrastructure, human resources, digital services, safety, teacher training and more. The indicators are used, among other things, by the local authorities, when they need information before equipping schools. While it is unclear how much autonomy is devolved to schools in decision making concerning technology, it appears that lower secondary and upper secondary schools do have a degree of flexibility regarding the use of government grants and in how they achieve national objectives. Priorities were set out in the digital strategy ‘Digital Technologies Serving a School or Trust’ in 2018.

Ireland

Many aspects of the administration of the Irish education system are centralised in the Department of Education which deals directly with most schools. Apart from the 16 Education and Training Boards (ETBs), which are responsible for the 265 vocational schools and community colleges, there is no regional or local structure for schools in Irish educational administration. Therefore, all primary schools (3262) and 470 of the 735 post primary schools deal directly with the Department of Education. Funds for digital strategies and initiatives are devolved directly to schools in the form of grants. Schools have a considerable degree of autonomy in how they spend the grants, as the focus has largely been about supporting schools and teachers to develop digital learning plans for their schools and make informed choices about the use of digital technology. Ireland's Digital Strategy for Schools 2015-2020 expired at the end of the 2020-2021 school year and a new strategy is currently in development.

Italy

The Ministry of Education in Italy, which also operates through regional school offices, is responsible for the general organisation of school education including setting educational objectives, curricula, staff training and qualifications, pupil assessment, safety measures in schools and the allocation of financial resources. Below the national level, the provinces have responsibility for upper secondary education, including responsibilities for premises, infrastructure and support for the purchase of resources. Municipalities have a similar level of responsibility for the provision of primary and lower secondary schools. Buildings and infrastructure are funded by the provinces or municipality, depending on phase, while school staff (teachers and other staff) are provided and paid by central government. Therefore, resources allocated by the state to schools are aimed at covering running costs for administrative and teaching purposes. Schools have full autonomy in setting up and participating in networks for pursuing their institutional aims. The Italian National Plan for Digital Schools was launched at the end of 2015 and intended to be implemented up until 2020. It is unclear whether this digital strategy for schools will be extended, discontinued, or replaced with a new one.

Japan

In Japan, decision making is managed through the three levels of government: national, prefectural, and municipal. At the national level, the Ministry of Education, Culture, Sports, Science and Technology (MEXT) is responsible for establishing the national curriculum, teachers' qualifications and pay, school planning and improvement. Prefectures play a significant role in resource and personnel management through regional boards of education which appoint teachers to primary and lower secondary schools and allocate funding to municipalities.

Municipalities are responsible for the supervision and day-to-day operation of schools. Within municipalities, there are boards of education appointed by the mayor. These boards are responsible for making recommendations to the prefectural board of education on teacher appointments, choosing textbooks from the MEXT-approved list, conducting in-service teacher and staff professional development, and overseeing the day-to-day operations of primary and lower secondary schools. In schools, principals are responsible for planning the school curriculum, based on the national curriculum, and for managing the schools' day-to-day activities. The Japanese Government has launched several initiatives to promote the increased use of technology in education, including the GIGA (Global and Innovation Gateway for All) school programme, which launched in 2019**.**

Netherlands

The Ministry of Education, Culture and Science administers almost all central government expenditure on education. The relationship between schools and the ministry is characterised by a large measure of institutional autonomy. Schools qualify automatically for funding, provided they meet the quality standards and funding conditions imposed by law for the school system as a whole. Every year, all government-funded educational institutions receive block funding to meet their personnel and running costs. They are free to decide how to use this money. Currently there is no strategy for digital education although a digitalisation agenda for primary and secondary education was announced in 2019 and the broader Dutch Digitalisation Strategy 2.0, introduced in the same year, includes digital skills in education.

Norway

The Norwegian National Assembly has adopted a decentralised administrative structure which delegates considerable authority and financial freedom of action to the local level. The administration of the education system is divided into three levels; central level, county level, and municipal level with different responsibilities. Centrally, the Ministry of Education and Research has the overall responsibility for policy and research in education at all stages. Responsibility for school management and administration, the intake of pupils and the appointment of teachers falls to counties for upper secondary schools and to the municipalities for kindergartens, primary and lower secondary education. The municipalities and counties draw most of their revenue from local taxes and from a national redistributive grant system. While the extent to which decision making is devolved to schools varies, the headteacher is responsible for both the administrative and pedagogical aspects of running the school and managing the school budget. The Ministry of Education has published a digitalisation strategy for primary, secondary and vocational education for 2017-2021.

Sweden

Sweden has a decentralised education system within an overall framework of goals and learning outcomes set by the government. The administration of the Swedish education system is decentralised to municipal level and there is no regional administrative level for education. Compulsory schools can be run either by municipalities or as grant-aided independent schools. For each school run by the municipality, the municipality establishes a local school plan (skolplan) describing the financing, organisation, development and assessment of the activities within each school from which the school then develops a work plan setting out how the objectives in the local plan and relevant national goals will be achieved. The school, or in most cases the teacher, decides what teaching resources and pedagogical methods to use. The majority of school funding comes from revenues from municipal taxes that are then allocated under different funding models depending on the municipality. School funding is also influenced by school choice, as funding is attached to students rather than schools, with pupils able to choose to attend school outside of their own municipality. Grant-aided independent schools are also funded by municipal grants from the pupils' home municipalities and by state grants, and are not allowed to charge fees. The National Digitalisation Strategy for the School System was published in 2017 with implementation intended to be complete by 2022.

United States of America

Though the United States Federal Government contributes almost 10% of the national education budget, education is primarily the responsibility of state and local government. It is states and communities, as well as public and private organisations of all kinds, that establish schools, develop curricula, and determine requirements for enrolment and graduation. The structure of education finance in the USA reflects this predominant state and local role. The state governments gather and distribute a significant amount of funding for schools through state sales and income taxes, lotteries, and property taxes. Local governments also often contribute through their respective taxation systems. The National Education Technology Plan (NETP) is the educational technology policy document for the USA which is updated every five years, with the current version published in 2017.

Comparative indicators of levels of the use of digital technology in schools

In a working paper published by the OECD, van der Vlies (2021) noted that education has not been at the forefront of digitalisation and that the COVID-19 crisis has shown that the familiarity with digital tools remains limited. Schools are faced with two challenges: the first is to ensure that teaching and learning can benefit from new tools and technology; the second is to equip students with the right skills and knowledge to enable them to fully participate in increasingly digitalised societies and workplaces. Key to both these aims is that students have sufficient access to technology in schools and that their teachers feel sufficiently competent to support students' digital learning and to maximise the opportunities offered by new digital learning tools.

The OECD publishes indicators which show the extent to which students use a computer at school, whether teachers feel a high-level need for additional information and computer technology (ICT) training and the percentage of school principals who believe that a lack of digital technology is impacting on their ability to provide good quality ICT teaching and learning in their school. Although some data is now fairly old, it is still useful to note the situation of the countries in the review, relative both to each other and the OECD average, as it indicates the starting point at which many developed their digital strategy for education.

Unfortunately, the indicator for computer use is based on fairly historic data and it is likely that ICT availability has improved since the data was gathered. All but **Estonia**, **Ireland**, **Italy** and **Japan** reported a higher level of computer use than the OECD average (no data was available for the **USA**), with **Australia** reporting that 93.7 % of pupils of compulsory school age used a computer at school in 2012 compared with an OECD average of 72 %.

On average, 17.5 % of lower secondary teachers across OECD countries reported having a high level of need for professional development in using technology in the classroom in 2018, with **Estonia**, **Finland**, **France**, **Japan**, **Norway** and **Sweden** all reporting a higher percentage of teachers needing development than the average. In **Japan**, almost 40% of lower secondary teachers identified this need. While information for primary school teachers was not available in most countries, where data existed, a higher percentage of primary school teachers in those countries reported a development need for ICT than secondary teachers in the same country except for Japan, where the percentage was broadly the same.

Finally, OECD indicators show that around a quarter of lower secondary school principals reported that a lack of technology was hindering high quality ICT instruction in their school in 2018. **France**, **Italy** and **Japan** reported that this was a problem in around a third of lower secondary schools, with Japan again with the highest percentage of principals reporting a lack of technology. Very few countries reported on this indicator for primary schools but, in France, this was an issue for almost 60% of primary school principals.

Table 1 sets out the indicators for each country in the review, where information is available.

Table 1: OECD Indicators

Country	Using a computer at school	High CPD needs (lower secondary)	Lack of technology (lower secondary)	High CPD needs (primary)	Lack of technology (primary)
Australia	93.7%	11.4%	N/A	N/A	N/A
Austria	81.4%	15.5%	17.8%	N/A	N/A
Czech Republic	83.2%	13%	23.5%	N/A	N/A
Denmark	86.7%	11.2%	12.7%	14.3%	17.4%
Estonia	61%	19.2%	11.9%	N/A	N/A
Finland	89%	19%	20.4%	N/A	N/A
France	N/A	22.9%	29.8%	34.6%	57.3%
Ireland	63.5%	N/A	N/A	N/A	N/A
Italy	66.8%	16.6%	30.9%	N/A	N/A
Japan	59.2%	39%	34%	38.8%	30.2%
Netherlands	94%	16%	16.2%	N/A	N/A
Norway	91.9%	22.2%	10.7%	N/A	N/A
Sweden	87%	22.2%	10.3%	25%	17.7%
USA	N/A	10.2%	19.3%	N/A	N/A
OECD average	72%	17.5%	24.6%	N/A	N/A

Source: OECD Education at a Glance 2021: OECD indicators

Description of indicators

- Using a computer at school: Percentage of pupils using a computer in school, OECD indicator 2012
- High continuous professional development (CPD) needs (lower secondary): Teachers in lower secondary reporting a high level of need for professional development in ICT skills for teaching), OECD indicator 2018

- Lack of technology (lower secondary): Percentage of principals who report that the delivery of quality instruction is hindered by a shortage of digital technology for instruction, lower secondary, OECD indicator 2018
- High CPD needs (primary): Teachers in primary reporting a high level of need for professional development in ICT skills for teaching, OECD indicator 2018
- Lack of technology (primary): Percentage of principals who report that the delivery of quality instruction is hindered by a shortage of digital technology for instruction, primary, OECD indicator 2018

Countrywide digital infrastructure

Many of the countries in this review have objectives to improve digital infrastructure such as greater internet speed and broadband access, often linked to moving access to public services online. This is usually separate from any digital strategy relating to schools, although schools would be expected to reap benefits from this. This section of the report explores the extent of investment in digital infrastructure in those countries and how it is supported and delivered.

Of the 14 countries in this report, 10 (**Austria**, **Czech Republic**, **Denmark**, **Estonia**, **Finland**, **France**, **Ireland**, **Italy**, the **Netherlands** and **Sweden**) are in the European Union (EU). The EU has developed a number of recommendations and programmes, often accompanied with funding, to support digital infrastructure. In addition, the European Commission has been monitoring member states' digital progress through the Digital Economy and Society Index (DESI) reports since 2014. Each year, DESI includes country profiles which support member states in identifying areas requiring priority action as well as thematic chapters offering a European-level analysis across key digital areas, essential for underpinning policy decisions. Analysis covers five key areas:

1. Human capital
2. Connectivity
3. Integration of digital technology
4. Digital public services
5. Research & Development in ICT

DESI 2021 Digital infrastructures (EU 2021) provides the following information:

- Overall fixed broadband take-up - over three quarter of EU households (77%) had a fixed broadband subscription in 2020. National take-up rates ranged from only 57% to 92%. The Netherlands was amongst those registering the highest figure, while Finland and Italy were amongst the lowest; although this may partly be due to fixed-mobile substitution.

- At least 100 Mbps fixed broadband take-up - in 2020, more than one third of EU households subscribed to such a service (34%), up from 2% eight years ago. More than 50% of homes in Sweden had this service in 2020, with Denmark and Netherlands also having above average take-up.
- Fixed Very High Capacity Network (VHCN) - VHCN coverage increased significantly between 2013 and 2020 from 16% to 59% in member states. Coverage almost doubled between 2018 and 2020, as the upgrade of cable networks to DOCSIS 3.1 started in several member states and FTTP (residential fibre to the premises) deployments also accelerated. Of the countries in this study, Denmark was well above average with over 90% coverage; Austria and Ireland were improving fast; the Czech Republic was amongst those countries with the lowest coverage in the EU.

While none of these indicators are specifically related to education, they can be indicative of the wider digital infrastructure in each country from which schools are a beneficiary.

In addition, the EU can provide funding for a range of digital projects in member states, including for infrastructure. The Digital Europe Programme supports projects in five key capacity areas: in supercomputing, AI, cybersecurity, advanced digital skills, and ensuring a wide use of digital technologies across the economy and society, including through Digital Innovation Hubs. With a planned overall budget of 7.5 billion euros (6.24 billion GBP), it aims to accelerate the economic recovery and shape the digital transformation of Europe’s society and economy, bringing benefits to everyone, but in particular to small and medium-sized enterprises. The Digital Europe Programme will complement the funding available through other EU programmes, such as the Horizon Europe programme for research and innovation and the Connecting Europe Facility for digital infrastructure, the Recovery and Resilience Facility and the Structural funds. It is a part of the next long-term EU budget: the Multiannual Financial Framework 2021-2027 (European Commission: the Digital Europe Programme, accessed 19/2/2022).

The communication 2030 Digital Compass: the European way for the Digital Decade (EU4Digital, 2021) reaffirms the crucial role of digital connectivity and sets ambitions for 2030: namely a Gigabit network for all European households and 5G in all populated areas. Following this communication, the Commission issued a proposal for a decision of the European Parliament and of the Council establishing the 2030 policy programme, Path to the Digital Decade, on 15 September 2021. The proposal sets out the concrete digital targets which the EU as a whole is expected to achieve by the end of the decade in four areas: digital skills, digital infrastructures, the increased use of digital technology in businesses, and the increased use of digital technology in public services.

The Connecting Europe Facility (CEF Digital) is intended to support an unprecedented amount of investment devoted to safe, secure, and sustainable high-performance infrastructure; in particular, Gigabit and 5G networks across the EU to support Europe's digital transformation, as outlined in the Path to the Digital Decade proposal. CEF Digital will foster public and private investments. The main actions foreseen under CEF Digital include:

- Deploying very high-capacity networks, including 5G systems, in areas where socioeconomic drivers are located;
- Guaranteeing uninterrupted coverage with 5G systems of all major transport paths, including the trans-European transport networks;
- Deploying new or a significant upgrade of existing backbone networks, including submarine cables, within and between member states and between the Union and third countries;
- Implementing and supporting digital connectivity infrastructure related to cross-border projects in the areas of transport or energy (EU, 2021 ANNEX to the Commission Implementing Decision on the financing of the Connecting Europe Facility – Digital sector and the adoption of the multiannual work programme for 2021-2025; EU CEF website, accessed 19/2/2022).

The following table sets out activities in the countries in this review relating to national digital infrastructure initiatives which may have implications and benefits for schools.

Table 2: Countries' fundamental digital infrastructure

Country	Initiative	Funding
Australia	The government, through the Department of Industry, Innovation and Science, is providing affordable high-speed broadband across Australia with the roll-out completed in 2020.	29.5 billion euros (15.4 billion GBP) of public equity investment was made in the National Broadband Network.

Country	Initiative	Funding
Austria	The Broadband Strategy 2020 aimed to provide nationwide ultrafast Internet access by 2020, in particular in areas where rollout for private companies is not economically viable to bridge the gap between town and country. Measures in the plan include: expansion of the geographical coverage of high-performance broadband networks; connection of existing stand-alone solutions to efficient data highways; and funding of the laying of ducting during construction work for non-discriminatory use for broadband networks. The strategy also requires net neutrality through regulation. The Austrian Government notes that “the more complex the interconnections, the more important it becomes to ensure compatibility and interoperability. Open standards encourage productivity, migratability for consumers, data protection and the economic value chain.” The public sector (including schools) is encouraged to use open standards (Digital Roadmap Austria website, accessed 23/2/22). The Broadband Office (“Breitbandbüro”) attends to all strategic and operative affairs around broadband (Ministry of Agriculture, Regions and Tourism website, accessed 23/02/22). This strategy is in the process of being replaced by Broadband 2030 which should supply the entire country with fixed-line and mobile gigabyte connections by the year 2030.	The Austrian Government committed to: funding expansion of broadband where this is not viable for the private sector; specifically fund excavation costs to provide a connection for schools or small and medium-sized companies; and develop a strategy to introduce the fifth generation of mobile telecommunications (5G strategy). The public sector committed a total of one billion euros (830 million GBP) of funding (Ministry of Agriculture, Regions and Tourism website, accessed 23/02/22). Broadband 2030 is being supported by 1.4 billion euros (1.2 billion GBP), 890 million (743 million GBP) of which comes from the EU Recovery and Resilience Facility.
Czech Republic	The National Plan for the Development of Very High Capacity Networks (VHCN),	The National Plan for VHCN estimates an

Country	Initiative	Funding
	approved in March 2021, defines the strategic approach of the Czech Republic to the construction of VHCN, with a particular focus on areas with no access to VHCN and where private operators do not intend to build them. The plan indicates the necessary preconditions facilitating investment in very high-capacity networks as well as defining strategic procedures for the construction of these networks and, at the same time, provides direct support from public sources while minimising interference in the market. The Ministry of Industry and Trade is the main responsible body for the plan.	investment gap for backhaul and access networks at CZK 15.3 billion (0.53 billion GBP). Based on the 75 % co-financing rate, the planned public support is circa CZK 11.5 billion (0.4 billion GBP). Use of funds from several funding sources is foreseen, including a number of EU funding streams: Integrated Regional Operational Program (IROP) 2021-2027, Connecting Europe Facility Program (CEF 2), Digital Europe Programme, Just Transformation Fund (JTF), InvestEU and Recovery and Resilience funding. (European Commission, Broadband in the Czech Republic, website accessed 23/02/2022)
Denmark	The Ministry of Climate, Energy and Utilities is responsible for Danish broadband policy development and administration. Its principal actions include the regulatory framework for the telecom sector and the setting of broadband goals, which are collectively agreed on by the government. The Agency for Digitisation is an agency of the Ministry of Finance and was established in 2011 to speed up the use of digital technology required to	Denmark's primary focus is on the roll-out of high-speed network infrastructure based on private investments. A key role is reserved for municipalities in coordinating and promoting the process in cooperation with telecommunication operators. Public funding

Country	Initiative	Funding
	modernise the Danish welfare society. The Danish Government, through the Digital Growth Strategy, set a target that by 2020 all households and businesses must have access to a broadband connection with a download speed of at least 100 Mbps and upload speed of at least 30 Mbps. The government has stated that broadband development should be market-driven, and regulation should be technology-neutral. The Danish Government is currently developing a new broadband strategy (European Commission, Broadband in Denmark, website accessed 23/02/2022).	is reserved for areas with poor broadband coverage. The Broadband Fund, administered by the Danish Energy Agency, provides support to close the connectivity gap of the estimated 6% of households and/or companies that still do not have high-speed-internet access. The government has provided DKK 100 million (11.25 million GBP) yearly since 2018 to support households and firms with poor broadband coverage.
Estonia	In 2009, the Ministry of Economic Affairs and Communications and the Estonian Association of Information Technology and Telecommunications (ITL) founded the Estonian Broadband Development Foundation (ELASA). The purpose of the Foundation is to give all residential houses, businesses and authorities a chance to connect to the next-generation broadband network with a transmission speed up to 100 Mbps. The roll-out of the high-speed middle-mile networks to sparsely populated areas, which were unlikely to be covered by market-driven deployment, involves laying over 6000 km of fibre-optic cables and the construction of network access points. These investments are intended to stimulate complementary deployments of last-mile connections by commercial telecom operators.	In total 208 million euros (174 million GBP) from the EU Recovery and Resilience Plan is devoted to digital objectives. The 24.3 million euros (20 million GBP) support for deploying VHCNs in rural areas is expected to ensure broader access to online services in 8000 sites (European Commission, Broadband in Estonia, website accessed 23/02/2022).

Country	Initiative	Funding
	Estonia updated the targets and measures for broadband as part of its Digital Agenda 2020 in early 2014. The strategy envisages full coverage with connections of at least 30 Mbps by 2020 and aims to promote take-up of ultra-fast subscriptions with at least 100 Mbps with the objective that these account for 60% or more of all internet subscriptions by the same year. With its 5G roadmap, Estonia would like to achieve 5G connectivity in major cities by 2023 and along transport corridors by 2025. Estonia is in the process of putting together the new broadband plan for 2021-2030.	
Finland	Finland ranks 13th in connectivity amongst the EU's 27 member states with 57% overall fixed broadband take-up. This is partly due to the high usage of mobile internet in Finland, with 4G networks close to saturation in certain areas and a lead in 5G readiness with commercial deployments under way. A significant urban-rural divide exists, as does a gap characterised by low population density and vast areas with comparatively low economic incentive to roll out connectivity networks. Finland's national broadband plan, the digital infrastructure strategy, is being implemented. Finland is currently focusing on delivering at least the gigabit connectivity objectives. By 2025, all Finnish households should have access to a connection of at least 100 Mbps and it should be possible to increase connection speed to 1 Gbps.	The government has reserved 5 million euros (4 million GBP) for 2021 to implement its national broadband plan (by 2025, all Finnish households should have access to a connection of at least 100 Mbps). In addition, for very high-capacity connections in rural areas, resources from the European Agricultural Fund for rural development will also be available for 2021-2027. Decisions regarding the total amount of funds have not been made at the time of writing. In addition, the multi-annual 2018-2022 digital Finland framework is being implemented for the digital transformation

Country	Initiative	Funding
	In June 2020, to support the implementation of the cyber security strategy (2019), the government published a resolution on digital security in the public sector that sets out the development principles and key services to be considered to increase resilience in cybersecurity. The 2020-2023 action plan for digital security in the public administration describes how the resolution will be put in practice (Digital Economy and Society Index (DESI) 2021 Finland).	of local governments, with funding of 400 million euros (332 million GBP) over the whole period. Cybersecurity has also received funds in relation to broader e-government, for instance via a 100 million euros (83 million GBP) project on a digitalisation, experimentation and deregulation strategy for public sector ICT. In Finland's Recovery and Resilience Plan, the contribution to digital objectives accounts for 574.3 million euros (482 million GBP). The focus of the plan is on public digital services, digital skills and digital transition of economy. Investments include data-driven innovation (37 million euros, 31 million GBP), cybersecurity (20 million euros, 16.8 million GBP), connectivity in the areas where the market mechanism cannot deliver (50 million euros, 42 million GBP), digital skills at various stages of education and life, and related digital public services (over 50 million euros, 42 million GBP), deployment of advanced

Country	Initiative	Funding
		technologies and digital R&D&I (43 million euros, 36 million GBP), and the digitalisation of businesses, including SMEs, innovation infrastructures, and grants for businesses development (40 million euros, 33.5 million GBP) (EC, 2021. Digital Economy and Society Index (DESI) 2021 Finland).
France	The national broadband programme, France Très Haut Débit, sets out the targets of fast broadband access for all households by 2022 with 100% coverage with 30Mbps, and fibre access for all by 2025. The National Agency for Territorial Cohesion (l'Agence Nationale de la Cohésion des Territoires) is responsible for implementing France’s broadband strategy (European Commission, Broadband in France, website accessed 23/02/2022).	French officials expect that the national strategy will require mobilisation of private and public investments of up to 20 billion euros (16.7 billion GBP). The Fund for the Digital Society (Fonds pour la société numerique) provides a combination of public loans and funding to support the roll-out of ultrafast broadband by the French Government. Infrastructure projects that are eligible include works on backhaul networks (FTTN), passive fibre optic networks (FTTH), customer access (FTTH), access for public institutions (education, health, public administration), support for Wi-Max and/or satellite

Country	Initiative	Funding
		receivers as well as feasibility studies for planned roll-out projects. France assigned 3.3 billion euros (2.8 billion GBP) to the implementation of the plan Très Haut Débit. An additional 240 million euros (200 million GBP) were allocated to boost connectivity in rural areas as part of the France's Recovery and Resilience Plan.
Ireland	The National Broadband Plan for Ireland, updated in 2021, sets targets for 2026. Its core objectives are to contribute to sustained macro-economic growth and competitiveness. In November 2019, the government signed the contract for the implementation of the national broadband plan. The contractor, National Broadband Ireland, will build a predominantly fibre-based network to cover 540,000 premises in Ireland with minimum download speed of 150 Mbps. Around 146.000 kilometres of fibre will cover 96% of Ireland's land mass. The National Broadband Plan aims at connecting all communities, as commercial operators have made it clear that there are parts of the country where they will not make high-speed broadband services available commercially. The intervention aims to provide high-speed broadband to every premises in the country with no existing or planned high-speed broadband network (European Commission,	In 2019, the European Commission approved, under EU State aid rules, 2.6 billion euros (2.18 billion GBP) of public support for the Irish National Broadband Plan to bring high-speed broadband services to consumers and businesses in areas with insufficient connectivity in Ireland (EC press release, November 2019). The allocation for connectivity through the Recovery and Resilience Plan is 19 million euros (16 million GBP). The connectivity measure will help public administrations maximise the benefit from 5G technologies. The investment consists of

Country	Initiative	Funding
	Broadband in Ireland, website accessed 24/02/2022).	building a low-latency platform with a high-speed backbone using edge compute nodes to enable a faster response.
Italy	The Italian Strategy for Ultra Broadband Towards the Gigabit Society, May 2021, has seven intervention areas: a) Plan for white areas b) Voucher plan c) Plan Italy 1 Giga d) Italy 5G Plan e) Connected Schools Plan f) Connected Health Plan g) Minor Islands Plan The Plan Italy 1 Giga, aims to provide 1 Gbps in download and 200 Mbps upload speeds in grey and market failure areas. The Italy 5G Plan aims to incentivise the deployment of 5G mobile networks in areas of market failure. A core aim of the Digital Italy 2026 Plan (MITD, 2021) is to make all public data interoperable. The Digital Italy 2026 Plan (MITD, 2021) also aims to provide 70% of Italians with a unique digital identity by 2026. Digital identity will become the main tool to access all public services.	Plan Italy 1 Giga has a planned allocation of 3.8 billion euros (3.2 billion GBP). Italy's 5G plan has an allocation of 2.02 billion euros (1.7 billion GBP). The Italian National Recovery and Resilience Plan allocates EUR 6.7 billion (5.6 billion GBP) for the implementation of the Strategy for Ultra Broadband. The plan provides allocations for the following five projects: Italy 1 Giga, Italy 5G, Connected schools, aiming to provide the state-of-the-art connectivity (at least 1 Gbps) to approximately 9,000 schools, Connected health care facilities, which intends to cover approximately 12,000 hospitals and healthcare facilities (at least 1 Gbps and up to 10 Gbps connectivity), andConnected smaller islands, aiming to deliver adequate connectivity to

Country	Initiative	Funding
		18 smaller islands through submarine fibre cables (European Commission, Broadband in Italy, website accessed 24/02/2022). In 2021 it was announced that the European Commission had approved, under EU State aid rules, 325 million euros (274.9 million GBP) of public support to connect 12,000 schools in Italy to very high-speed internet by 2025 (European Commission, State aid, January 2021).
Japan	In January 2016, the Japanese Government disseminated information on the Fifth Basic Plan for Science and Technology (2016–2020). The initiative is called “Society 5.0”, and it seeks to create a sustainable society which contributes to the safety and comfort of individuals based on a specific cyberphysical system. Society 5.0 defines a system of systems. In it, several systems (such as energy management and highway transportation systems, among others) are connected on the Internet for the mitigation of both local and global social problems (such as the reduction of carbon emissions). This new model of society is established in IT infrastructures, which include networks, cloud computing, data centres and big data. In Society 5.0, a huge amount of information from sensors in the physical	The aims of Society 5.0 are promoted through a series of plans setting out immediate priorities. The Sixth Basic Plan for Science, Technology and Innovation (STI) was adopted on 1 April 2021 with three main themes: (1) social structural reform, (2) fundamental strengthening of research capacity, and (3) development of human resources to support a new society. It includes provision for the development and R&D of next-generation infrastructure, beyond 5G, supercomputers, space

Country	Initiative	Funding
	space is accumulated in cyberspace. In cyberspace, this big data is analysed by AI, and the analysis results are fed back to humans in physical space in various forms. Infrastructure integration within Society 5.0 revolves around high-speed broadband connections (Narvaez Rojas et al., 2021; Cabinet Office, Government of Japan, website accessed 24/02/2022).	systems, quantum technology, semiconductors, and data/AI utilisation technologies. This R&D will be supported by a 30 trillion JPY (194.2 billion GBP) investment from government, with the expectation of industry investing 90 trillion JPY (584.4 billion GBP) (Office of Science and Innovation Tokyo, 2021).
Netherlands	The Netherlands markets itself as the digital gateway to Europe and is considered one of the most wired countries in the world. The country has consistently ranked first in the annual DHL Global Connectedness Index (United States International Trade Administration 2021). All households in the Netherlands should have the opportunity to access broadband networks of at least 100 Mbps and a vast majority should be taking advantage of 1 Gbps by 2023 (European Commission, Broadband in the Netherlands). The Dutch broadband strategy opts for a market-based infrastructure roll-out. It also puts key emphasis on the role of local and regional actors in coordinating and simplifying the process. Most of the broadband infrastructure roll-out is done by private operators autonomously. Here, removing barriers and facilitating the exchange of information and best practices among stakeholders are the	Although there are no state aid measures foreseen on a national level, a number of regional authorities are investigating the possibilities of state aid measures. The national government supports these authorities in this and is working on a framework for state aid. There is an umbrella scheme currently under development, which will make it easier for local authorities to provide financial support for construction (European Commission, Broadband in the Netherlands).

Country	Initiative	Funding
	principal tasks of local governments to stimulate investment by operators (European Commission, Broadband in the Netherlands website accessed 25/02/2022). The Netherlands has also established itself as a cybersecurity hub (see section on cybersecurity).	
Norway	Norway is one of the most extensively digitalised countries in the world. The Digital Economy and Society Index (DESI, 2020) shows that Norway is clearly improving in the areas of digital infrastructure (broadband and mobile network coverage), digital public services and digital skills. According to the survey, Norway's population has the highest rate of internet activity, and more than 90% make use of digital public services or contact government agencies online. Norway's score is particularly high when it comes to online public administration processes and digital services for business. Along with Denmark, Norway's access to mobile networks and broadband connectivity is the highest in Europe. By the end of 2020, Norway had reached the target of 90% of households being offered high-speed broadband of more than 100 Mbps. The new target is that 100% of households should have access to 100 Mbps by 2025. The Broadband Development Act came into force on 1 July 2020. This legislation is intended to make it simpler for developers to access existing infrastructure like utility poles and pipes, thereby reducing the complexity and cost of further developing broadband. The government expects that	Since 2012, more than NOK 70 billion (5.9 billion GBP) has been invested in digital infrastructure, and substantial resources have been expended to ensure that it is safe and well prepared to withstand the onslaught of harsh weather as well as cyberattacks. In 2019 the private network companies invested more than NOK 12 billion (1 billion GBP) in mobile and broadband networks. The government contributes with subsidies for the development of broadband connectivity in areas where this is not profitable for commercial developers. Since 2014, more than NOK 1.5 billion (126 million GBP) has been allocated for this purpose. These funds are distributed so that those with the greatest unresolved requirements receive the most, with county councils being

Country	Initiative	Funding
	this will speed up the development of high-capacity networks and give Norwegian citizens more broadband at a lower cost (Norway, Ministry of Local Government and Regional Development website, accessed 25/02/2022).	responsible for allocating the money. Additionally, there is government support for telecom safety and emergency preparedness (Norway, Ministry of Local Government and Regional Development website, accessed 25/02/2022).
Sweden	The 2015-2018 Digital First agenda of the Swedish Government has five core areas of work covering digital government efforts: 1. A national digital infrastructure 2. Digital maturity 3. Capacity for digital innovation 4. One agency for digital government 5. Legal reform for digital first Sweden's national broadband plan, adopted in 2016, has the vision of an entirely connected Sweden and has goals for both mobile coverage and for high-speed broadband connections for households and businesses. By 2020, 95% of all households and companies should have access to broadband at a minimum capacity of 100 Mbps and by 2025, all of Sweden should have access to high-speed broadband. In its broadband strategy, A Completely Connected Sweden, the Swedish Government has identified three strategic areas in order to meet the goals set in the strategy: roles and rules on the broadband market; cost-efficient expansion of the broadband	The government established a digitalisation agency in 2018 with the responsibility for coordinating and supporting the increased use of digital technology in the public sector with an allocated budget of 102 million Swedish krona (8.2 million GBP) in the 2018 Budget Bill. According to the provisions of the bill, these funds should be used to cover the expenses of the new agency, coordinate and support interagency efforts to increase the use of digital technology, the national digital infrastructure and open data. As a result, the use and allocation of financial resources for the development of the digital infrastructure and open data is intended to

Country	Initiative	Funding
	infrastructure; and services for everyone. The focal point is people's need for broadband access, whether they live in densely populated areas, scarcely populated areas and rural areas, or in areas situated in between. Sweden is also committed to be at the forefront of the development of 5G (European Commission, Broadband in Sweden, website accessed 25/02/2022).	increase control over high-risk and strategic ICT projects and to align all agencies efforts in updating the IT infrastructure for the public sector (OECD, Digital Government Review of Sweden 2018). State aid for broadband deployment in areas where there are no commercial investments in next generation access networks is available through the Agricultural Fund for Rural Development (EAFRD) and in the northern part of Sweden via the European Regional Development Fund (ERDF). SEK 202.8 million (16.1 million GBP) is provided to the Rural Development Programme for 2014–2020 for continued broadband expansion in rural areas. Financed through the Recovery and Resilience Fund, the government intends to invest SEK 1.4 billion in 2021 (111.2 million GBP), SEK 500 million (39.7 million GBP) in 2022 and thereafter SEK 100 million (8 million GBP) annually during 2023-2025 to expand

Country	Initiative	Funding
		broadband throughout the country and achieve the national broadband targets. During the current programme period for the rural development programme (2014–2020), the government has also allocated approximately SEK 4.45 billion (357.3 million GBP) in broadband support for expansion in areas where it is not commercially profitable to expand. The government has also made investments of SEK 1.2 billion (95 million GBP) within the regional fund for the expansion of larger local interconnection broadband networks in the three northern regional fund programmes (European Commission, Broadband in Sweden, website accessed 25/02/2022).
USA	The National Telecommunications and Information Administration's (NTIA) BroadbandUSA programme promotes innovation and economic growth by supporting efforts to expand broadband connectivity and meaningful use acrossthe USA. BroadbandUSA provides resources to state, local, and tribal governments, industry, and non-profits, including a Federal Funding	At the beginning of April 2016, the Federal Communications Commission (FFC) voted to modernise the Lifeline programme, originally a Reagan-era phone subsidy programmme, to turn it into a 21st Century national broadband subsidy to help low-

Country	Initiative	Funding
	Guide and Indicators of Broadband Need Map. ConnectHome is a United States Department of Housing and Urban Development programme focused on increasing access to high-speed internet for low-income households. The pilot programme launched in 27 cities and 1 tribal nation in the summer of 2015, initially reaching more than 275,000 low-income households and nearly 200,000 children. As part of the programme, internet service providers, non-profits, and the private sector will offer broadband access, technical training, digital literacy programmes, and devices for residents in assisted housing units.	income Americans get online. The modernisation also set a floor for broadband speeds paid for by the subsidy to help ensure Lifeline users aren't subscribing to second-rate internet. The budget for 2020 was $2.385 billion (1.8 billion GBP), to be index-linked for future years (FFC website, accessed 25/02/2022).

Source: Appendix 1 country reports

While all countries in this report are supporting and/or investing in broadband, for a number (**Austria**, **Czech Republic**, **Denmark**, **Estonia**, **Finland**, **France**, **Ireland**, **Italy**, **Norway** and **Sweden**) a key objective is to ensure coverage extends to rural areas, providing funding as this would otherwise not be commercially viable for private providers. For those countries in the EU, this is often supported with funding from the EU itself. The **Netherlands**, however, has opted for a market-based infrastructure roll-out with an emphasis on the role of local and regional authorities in coordinating and simplifying the process for providers, although the national government is working on a framework to support local authorities to apply for state aid to support construction. For **Australia** and the **USA**, a major objective is affordability for low-income households, with funding directed towards supporting this.

The majority of countries also have stated ambitions for increasing the coverage of high-speed broadband and 5G networks; for those in the EU, individual countries' digital plans often reflect the aims of the European digital strategy.

A number of countries include provision for cybersecurity in their digital infrastructure plans; for **Japan's** Society 5.0 initiative, which seeks to build a 'cyberphysical' interconnected system, cybersecurity will be of paramount importance.

The importance of interoperability is stressed by both **Austria** and **Italy** and is integral to **Estonia's** approach to the use of digital technology (see Case study: digital transformation in Estonia) and **Japan's** ambitions for Society 5.0. However, it does not seem to be a strong focus for other countries currently.

Case study: digital transformation in Estonia

Estonia does not have a separate digital strategy for schools; rather, the country has taken a broader approach to the use of digital technology across the whole public sector for some time which does not result from a single, unified strategy or sequence of strategies. It has been argued (Kattel and Mergel, 2018) that Estonia's digital transformation has resulted from a number of ad hoc and informal developments; policy documents that have followed the rhythms of European (structural) funding periods; and various overlapping and mostly self-managed public-private networks.

Estonia's digital transformation started in the early 1990s (when the country regained its independence) and has been characterised by widespread cross-party support. The aim is for public digital architecture that is universal in nature and empowers citizens but with decentralised digital agendas of the ministries: "[G]overnment ICT projects could not afford to build massive systems run by large vendors. Instead, the government was encouraged to embrace a distributed architecture of IT systems to cater to the different needs of each government agency. This became an explicit strategy from 1999 onwards: ministries were asked to build their IT systems according to their specific needs, but ensuring frugality and interoperability across government" (Kattel and Mergel, 2018). This approach required a mechanism by which these distributed systems could exchange data with each other. This led to the development of 'x-road' as a layer for secure data exchange. This approach led to centrally set design principles:

- no legacy principle: public digital infrastructure should not use technological solutions that are older than 13 years
- build versus buy principle: the priority is to build systems from scratch rather than buying 'off-the-shelf' software systems from ICT vendors (particularly true for Estonia in the early stages of digital transformation)
- once only principle: businesses and citizens have to supply information for government authorities only once and data is available across government agencies through the data exchange layer x-road
- interoperability and security principle: rather than seeking to create unified databases and information systems
- a deliberate focus on public-private networks rather than on individual organisations (Kattel and Mergel, 2018)

While this section looked at infrastructure more broadly than that which supports schools, it is clear that the emphasis on coverage of high-speed broadband will benefit schools, particularly those in rural areas, and enable them to take better advantage of digital resources. Enhanced high-speed coverage will also enable pupils, parents and carers to interact with schools more effectively through digital portals and in accessing digital resources to support learning at home. Initiatives in **Australia** and the **USA** to increase the affordability of broadband for low-income households are also likely to benefit children.

Strategic approaches to increasing the use of digital technology in schools

This section provides an overview of the strategic approaches to increasing the use of digital technology in schools in the different countries included in this review.

Types of digital strategies

Seven of the countries have a national digital education strategy (**Austria**, **France**, **Ireland**, **Japan**, **Norway**, **Sweden** and the **USA**).

Table 3: Countries that have a national digital education strategy

Country	Summary description
Austria	In Austria, a digital strategy of four pillars was launched in 2017 for implementation from 2017-2018. In 2020, this strategy was replaced by the national Digital Master Plan for schools, which builds on the earlier strategy and other initiatives.
France	In 2015, France introduced a new digital strategy for schools called Schools Change with the Digital Age. This represented France's biggest national digital plan for education ever. The strategy was renamed Digital Technologies Serving a School of Trust in August 2018.[1]
Ireland	Ireland's Digital Strategy for Schools 2015-2020 expired at the end of the 2020-2021 school year; however, in April 2021, Ireland's Minister for Education announced that a new Digital Strategy for Schools was to be developed. On 1 February 2022, the minister reported that the digital strategy is currently in the final phases of development (Dáil Éireann Debate, 1 February 2022).
Japan	Japan has introduced several initiatives (and plans) to promote the use of digital technology in education and innovation as part of a government push toward a post-

[1] Digital in the service of the school of trust (Le numérique au service de l'école de la confiance) (Ministère de l'Éducation Nationale and Ministère de l'Enseignement Supérieur, de la Recherche et de l'Innovation 2018)

Country	Summary description
	information society called Society 5.0, incorporating cyberspace, such as AI, big data and the Internet of Things. Recently, the most prominent initiative has been the GIGA (Global and Innovation Gateway for All School Program, which was launched in 2019. GIGA is a joint initiative by the International Telecommunication Union (ITU) and the United Nations Children's Fund (UNICEF) initiative, which was launched in 2019. It aims to provide connectivity (access) to every school in the world. GIGA acts as a convener between funding opportunities and connectivity projects for schools, and works with national governments, mainly in low and middle-income countries, to map connectivity within schools before devising a plan for improving connection and digital readiness. Japan’s GIGA programme is tailored to its own aims for all students to have access to their own device, which has led to a push for school connectivity, as well as device distribution (Unicef, October 2021).
Norway	The Ministry of Education and Research in Norway published a digitalisation strategy for primary, secondary and vocational education covering 2017-2021. In addition to the strategy, in 2020 the Ministry published an Action Plan for Digitalisation in Primary and Secondary Education and Training.
Sweden	In Sweden, the National Digitalisation Strategy for the School System (2017) was followed up, in 2019, with an action plan developed by the Swedish Association of Local Authorities and Regions (SALAR) which recommended 18 different initiatives to support the strategy.
USA	The National Education Technology Plan (NETP) is the flagship educational technology policy document for the USA. First released in 1996, this has been updated every five years since, and the Office of Educational Technology is currently working to update and expand upon the vision presented in the 2017 NETP.

Source: Appendix 1 country reports

In four of the countries that currently do not have a national digital education strategy, digital education is part of their national education strategy (**Czech Republic**, **Denmark**, **Estonia** and **Finland**).

Table 4: Countries that include digital education in a national education strategy

Country	Summary description
Czech Republic	In the Czech Republic, it is not clear whether or when a new digital education strategy will be introduced to replace the Digital Education Strategy to 2020. However, digital education is a key pillar of the Strategy for the Education Policy of the Czech Republic up to 2030+, which was launched in October 2020.
Denmark	There is no single digital strategy, nor an education strategy restricted to schools. However, there are two education strategies that cover early learning and adult education and training, as well as schools, and which also encompass objectives relating to the increased use of digital technology in schools.
Estonia	In Estonia, there is no single digital strategy nor a digital education strategy restricted to schools. However, the Estonian Education Strategy 2021 - 2025 (adopted in November 2021 by the government) covers early learning and adult education and training, as well as schools, and also includes objectives relating to the increased use of digital technology in schools.
Finland	In Finland, the strategic education programme of 2015 included, as one of its five projects, New Learning Environments and Digitalisation. A new strategic programme was published by the government in December 2019 (Eurydice 2021c) but it is not clear from the Anglophone literature whether this contains any specific aims relating to the increased use of digital technology in schools.

Source: Appendix 1 country reports

In two of the countries that currently do not have a national digital education strategy, digital education is part of their national digital strategy (**Italy** and the **Netherlands**).

Table 5: Countries that include digital education in a national digital strategy

Country	Summary description
Italy	The Italian National Plan for Digital Schools (*Piano Nazionale Scuola Digitale, PNSD*), which was launched at the end of 2015, comprised 35 different actions that were intended to be implemented up to 2020. It is not clear whether the PNSD will be discontinued, extended or replaced; however, the Digital Italy 2026 Plan includes commitments to improve connectivity and interoperability in the school sector.
Netherlands	The Netherlands does not have a digital strategy for education; however, in 2019 the government established a digitalisation agenda for primary and secondary schools. Moreover, digital education is included in the Dutch Digitalisation Strategy 2.0, which was introduced in the same year.

Source: Appendix 1 country reports

There is no overarching national digital strategy for **Australia**, although the national government does provide financial support for initiatives related to digital aspects of the curriculum. Responsibility for public schools lies predominantly with the states and territories and two states (**New South Wales** and **South Australia**) have produced digital strategies.

Focus areas for digital strategies

Table 6 shows which areas are covered by the digital education strategies in countries reviewed in this research.

Table 6: Areas covered by digital education strategies

Focus of the aims of digital strategies/plans	Number of countries
Development of teachers' digital skills	12
Promotion of new approaches to teaching and learning	12
Improved digital infrastructure in schools	10
Improved connectivity for schools	9
Changes to the curriculum	9
Improved use of educational data	9
Promotion and/or development of digital learning resources	6
Students' access to computers and digital tools	5
Data protection and ethical issues	5
Development of school leaders' digital skills	5
Provision of technical support for schools/teachers	5
Provision of pedagogical support/mentoring for teachers	4
The use of technology and simplification of school administration	4
Stimulating and disseminating innovation	4
AI / robotics	3
Research on the impact of the increased use of digital technology in schools	3

Source: Appendix 1 country reports

Issues mentioned by only one country include: common public standards for technology in schools (**Denmark**); supporting partnerships between companies and schools (**France**); public understanding of the importance of digital technologies in education (**Czech Republic**); and children with special needs (**Japan**).

Table 7 sets out the main areas covered by the different countries' digital education strategies, plans or stated priorities.

Table 7: Areas covered by the digital education strategies of different countries

Country	Teachers' digital skills	Teaching and learning	Connectivity	Digital infrastructure in schools	Curriculum	Educational data	Digital learning resources	Access to hardware	Data protection / ethics	Leaders' digital skills	Technical support	Pedagogical support	School administration	Innovation	AI/Robotics	Research
Australia (NSW)	Y	Y	Y	Y	N	N	N	Y	N	N	N	Y	N	N	N	N
Australia (SA)	Y	N	N	Y	N	Y	Y	N	N	Y	N	N	N	N	N	N
Austria	Y	Y	Y	Y	Y	N	N	Y	N	N	Y	N	Y	N	N	N
Czech Republic	Y	Y	N	Y	Y	Y	N	N	N	N	N	Y	N	Y	N	N
Denmark	Y	Y	Y	Y	Y	Y	N	N	Y	Y	N	N	N	N	N	Y
Estonia	Y	Y	N	N	Y	Y	N	N	N	N	Y	N	N	N	N	N
Finland	Y	Y	N	N	Y	N	N	N	N	N	Y	Y	N	Y	Y	N
France	Y	Y	N	N	Y	Y	Y	N	Y	N	N	N	Y	N	Y	N
Ireland	N	Y	Y	Y	Y	N	N	N	N	N	N	N	N	N	N	N
Italy	Y	Y	Y	Y	N	N	Y	Y	N	N	Y	N	Y	Y	N	N
Japan	Y	N	Y	Y	N	Y	N	Y	N	N	N	N	N	N	Y	N
Netherlands	N	N	Y	Y	Y	Y	Y	N	Y	N	N	N	N	Y	N	N

Country	Teachers' digital skills	Teaching and learning	Connectivity	Digital infrastructure in schools	Curriculum	Educational data	Digital learning resources	Access to hardware	Data protection / ethics	Leaders' digital skills	Technical support	Pedagogical support	School administration	Innovation	AI/Robotics	Research
Norway	Y	Y	N	N	N	N	Y	N	Y	Y	N	N	N	N	N	Y
Sweden	Y	Y	N	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	N	N	Y
USA	Y	Y	Y	Y	N	Y	N	N	Y	Y	N	N	N	N	N	N

Source: Appendix 1 country reports

Implementation

Table 8 indicates where responsibilities for implementing digital education strategies and plans largely lie in the fourteen countries.

Table 8: Level at which responsibility for implementation is delegated

Country	Central	Regional/State	Local	School
Australia (NSW)	N	Y	N	N
Australia (SA)	N	Y	N	N
Austria	N	N	N	Y
Czech Republic	N	N	N	Y
Denmark	Y	N	Y	N
Estonia	N	N	N	Y
Finland	N	N	Y	Y
France	Y	Y	Y	N
Ireland	N	N	N	Y
Italy	N	N	N	Y
Japan	N	Y	Y	N
Netherlands	N	N	N	Y
Norway	N	N	Y	N
Sweden	N	N	Y	N
USA	N	Y	Y	N

Source: Appendix 1 country reports

Responsibility for the implementation of digital education strategies and plans appears to be largely delegated to schools in **Austria**, the **Czech Republic**, **Estonia**, **Ireland**, **Italy** and the **Netherlands**. In **Austria**, the Digital Master Plan sets out a central offer with the decision to participate in many aspects being made by the school. Schools are also expected to develop their own digital strategy. Schools in the **Czech Republic** are also responsible for developing their own ICT plans (although they are not obligated to do so) and most schools have an ICT co-ordinator (European Schoolnet, 2018)[2]. **Ireland's** previous Digital Strategy for Schools 2015-2020 delegated responsibility for implementing digital strategy to schools on the basis that they "are best placed to identify the requirements of their own student cohort and to meet those requirements", and it is likely that the country's new digital strategy for schools will adopt a similar approach. Ireland's Department of Education does have levers at its disposal, however, such as curriculum frameworks, teacher training and a national support service for schools on digital technologies, which enable it to improve the knowledge and use of digital technology in schools. In the case of **Italy**, apart from broadband connectivity, it appears that the PNSD (which recently expired) was also largely focused at school level. The main drivers of the adopted strategy were to significantly increase the funds invested; to target schools and teachers eager and ready to initiate change; and to stress pedagogical uses of technology and to conduct experiments (Bottino, 2020). We were unable to find information for **Estonia** or the **Netherlands** in the Anglophone literature**,** but the systems in both countries are highly decentralised to the school level, and there is a high degree of school autonomy.

In **Finland**, **Norway** and **Sweden**, local government has greater levels of responsibility for the implementation of digital strategies and plans. In **Finland**, decisions are mostly the responsibility of local education authorities (generally municipalities) and schools (OECD, 2020), with strong stakeholder participation within a relatively loose strategic framework set by central government (OECD, 2020; MINEDU, 2018; Saari and Säntti, 2018). Central government does have some levers available to it, including setting the national curriculum and developing national strategies, although implementation of these is devolved in a way that allows for local interpretation. In **Sweden,** responsibility for strategy implementation falls to the municipalities and there seems to be little in the way of central coordination. While the national government has developed a digital strategy for schools and is able to influence the use of digital technology in schools through curriculum content and digital tests, it lacks many levers to ensure its ambitions are fully realised. In **Norway**, although we can find no evidence in the Anglophone literature of the strategy providing a rationale for decision making levels[3], governance of the education system reflects a long-established tradition of decentralisation, with the municipalities having most of the responsibility for the implementation of the strategy. The

[2] It is unclear to what extent regional administrations, which are responsible for education on their territory (and are school founders for upper secondary schools) and municipalities (which establish basic schools), influence the implementation of digital education strategie and /plans.

[3] NB a full English translation is not available.

municipality/county administration influences the extent of self-governance in schools in the municipality/county (Eurydice, 2021a).

In Japan and the USA, responsibilities for the implementation of digital education strategies and plans are primarily at regional and local levels. In **Japan,** regional authorities (prefectures) and local government (municipalities) are largely responsible for digital infrastructure in schools. However, in the case of the GIGA programme, the government not only subsidises but also guides technology procurement, promotes the use of high-quality digital textbooks and teaching materials, and publishes guides on technology education and digitally enabled teaching of traditional subjects (Mckinsey and company, February 2021). In the **USA,** implementation of the national digital strategy is primarily the responsibility of the states and school districts. In 2014 the federal government removed the requirement for school districts to submit three-year technology plans to their state's department of education. However, some states still require or recommend that districts continue with the practice of creating a three-year technology plan and provide guidance on requirements for a good technology plan. The extent of school involvement in decisions regarding implementation varies as school districts delegate varying amounts of freedom or independence to each individual school within their sector.

In **Australia**, implementation primarily rests at state level where responsibility for public schools lies. While not provided as rationales, the approach to the use of technology in schools from the commonwealth government, with its focus on curriculum implementation, reflects the limitations of the role of central government in effecting change in schools. The digital strategy in **New South Wales**, on the other hand, reflects the role of the state government in a state in which there is limited school autonomy.

Denmark and France are the only countries in which central government has a direct role in the implementation of digital strategies. In **Denmark**, responsibility is divided between central government and local government (municipalities), with the former responsible for public infrastructure and IT standards, and the latter for digital infrastructure in schools, learning management systems etc. codified in an agreement between the government and the association of local authorities. In **France**, central government shares responsibilities for implementation with regional authorities and local government (*départements).* At the ministry level, the Directorate of Digital Technologies for Education (*la Direction du Numérique pour l'Education (DNE*)) is responsible for matters related to ICT in schools. The mission of the DNE is to stimulate and support the digital transformation of the education system. It coordinates the actions of the Ministry of National Education in terms of information systems, development of digital services and digital innovation, development of digital culture and management of digital skills. At regional level, ICT advisors oversee the actions related to ICT in regional education authorities and coordinate the various networks of people and partners involved in ICT in schools. At local government level, the directors of the *départements'* education services are responsible for coordinating and implementing education policy. Under the authority of the head of region (*Recteur)*, they implement the academic strategy organizing educational action in schools, colleges, high schools and special education establishments in their department (European Schoolnet, 2018).[4]

[4] The role of directors

Funding

Specific funding is attached to digital strategies and plans in 9 of the countries included in this research (**Australia**, **Austria**, **Denmark**, **Finland**, **France**, **Ireland**, **Italy**, **Japan** and the **Netherlands**), although the amounts and scope of the funding varies considerably.

The funding is devolved to: schools in **Australia** (**NSW**), **Ireland** and **Italy**; regional and local government in **France** and **Japan**; local government in **Denmark**; local government and education providers in **Finland**; and a specialist government-funded digital unit in **Australia** (**SA**). In **Austria**, the funding is largely intended to develop central offers of resources, training and support. Information is not available for the Netherlands.

Four countries offer no specific funding linked to the strategies (**Norway**, **Sweden**, **USA** and **Estonia**). We were unable to establish whether funding is linked to national digital strategies and plans in the **Czech Republic**.

Table 9 summarises the availability of central government funding specifically attached to digital strategies and plans.

Table 9: Funding attached to digital education strategies and plans

Country	Amount (GBP conversions are approximate)	Notes
Australia (NSW)	191 million GBP ($365.8 million) 2020-2022	In New South Wales, funding for the schools digital strategy is part of a broader fund for the increased use of digital technology in public services, Digital Restart Fund (DRF), which has an overall budget of $1.6 billion (approx. 836 million GBP) over a three-year period. In June 2021, the NSW government announced that an extra $500 million (£261 million GBP) would be added to the fund over 3 years. Closing the digital gap between regional and metropolitan schools has, so far, received the largest allocation of DFR funding. The state government, in November 2020, announced that, over 2 years, $365.8 million (191 million GBP) is to be invested in teacher training, infrastructure, and digital platforms with automation capabilities. A total of $85 million (44 million GBP) of this funding was immediately released to 97 schools through the DRF. Budget

Country	Amount (GBP conversions are approximate)	Notes
		allocations are announced annually, so there is no figure available for the seven-year lifespan of the strategy.
Australia (SA)	17 million GBP ($33 million) 2022 –	In February 2022, the government of South Australia announced that the new strategy will be supported with a $33 million (17 million GBP) investment to create a new specialist Digital Guarantee Unit made up of curriculum specialists and ICT experts, who will be responsible for providing holistic support to schools to meaningfully integrate digital technology into what students learn and how they learn it. The unit will also be responsible for delivering on the strategy's commitment to equity in students' access to technologies. $23 million (12 million GBP) of new spending will be invested to improve access to devices for students, as well as provide home-based internet solutions for families where cost is a barrier. In addition, the unit will help to build digital capacity within the teaching workforce through tailored training and support, and work with schools to ensure all teachers have a quality device to support their work.
Austria	208 million GBP (250 million euros) 2020-2024	In 2020, the Austrian Government announced funding of 250 million euros by 2024 to support the implementation of the Digital Master Plan. No Anglophone information could be found for the details of this funding, but it seems most likely, given the autonomy of school decision making and the details of the central offer, that the funding is largely intended to develop central offers of resources, training and support.
Czech Republic	Information not found	We were unable to find information the Anglophone literature regarding the budgets associated with either the Czech Republic's Digital Strategy to 2020

Country	Amount (GBP conversions are approximate)	Notes
		or the Strategy for Education Policy of the Czech Republic Up To 2030: Digital learning.
Denmark	56 million GBP (DKK 500m) 2012-2017	Denmark’s government provided central funding to support municipalities’ investment in digital learning resources and for a pilot programme to develop teachers’ competences; otherwise, funding for implementation is the responsibility of the municipalities. Between 2012 and 2017, DKK 500m (Approx. 56m GBP) of government funding was provided to support the use of technology in primary and lower secondary schools and this was primarily spent on supporting municipalities’ investments in digital learning resources (50 % of cost) and research (Finn Togo, 2019). It is not clear what the definition of ‘learning resources’ includes. We were unable to find more recent figures in the Anglophone literature.
Estonia	Estonia’s education strategy has no funding attached to it in the literature although reference is made by the government to an expectation of a degree of EU funding (although the strategy is broader than the use of technology and the funding seems to be related to school reorganisations).	Because of the diffuse nature of the use of digital technology in Estonia over the last 30 years, the involvement of private sector funding and that education was seen as part of a much broader process of transformation, it has not been possible to identify funding related to particular strategies.

Country	Amount (GBP conversions are approximate)	Notes
Finland	74 million GBP (90 million euros) 2016-2019	In Finland, the government provided 90 million euros (75 million GBP) between 2016 and 2019 to support the comprehensive action plan. This breaks down into 50 million euros (41.5 million GBP) for funding teacher education and in-service training and 40 million (33.5 million GBP) for Experiments with Digital Learning. Within this, 23 million euros (19 million GBP) was provided by the government to train and support a network of tutor-teachers. In addition, education providers estimated that they contributed 2.5 million euros (2 million GBP) from their own funds to the programme. In 2017-2018 around 10 million euros (8.5 million GBP) were allocated to municipalities to hire tutor-teachers to support the use of digital tools. However, this funding linked to the Strategic Programme and accompanying plans and projects seems to reflect a more long-standing tradition: over the past 20 years, the Finnish National Agency for Education has annually allocated about 15 million euros (12.5 million GBP) for supporting the development of digital learning environments and for supporting teachers' professional learning of digital pedagogy through training and development projects.
France	0.85 billion GBP 2015- (One billion euros)	Public funding for digital education development in France is estimated at one billion euros (0.85 billion GBP), although it is not clear whether this was for the period 2015-2018 (as indicated by Watkins 2017) or ongoing. It is not clear from the literature how this funding is delegated, but the structure of the education system suggests funding will be largely delegated to the regions and local government.
Ireland	166 million GBP 2021- 2027 (200 million euros)	The Department of Education in Ireland has earmarked 200m euros (167 million GBP) to fund the implementation of policies developed under the

Country	Amount (GBP conversions are approximate)	Notes
		new Digital Strategy for Schools up to 2027. The previous Digital Strategy for Schools 2015-2020 involved a total investment of 210 million euros (175 million GBP) by way of an Infrastructure Grant for schools.
Italy	0.91 billion GBP (1.1 billion euros) 2015-2020	The PNSD was endowed with 1.1 billion euros in funding from existing sources. A total of 650 million euros (538 million GBP) was spent on digital infrastructure, including broadband and Wi-Fi connection. The rest was directed to fostering the acquisition of digital competences, teacher training for innovative practices, and other accompanying measures. To receive funds in the five areas of intervention (tools, skills, content, staff training, and supporting measures) schools were required to submit project proposals to open competitions.
Japan	2.95 billion GBP (461 billion JPY) 2019-2020.	The budget for the GIGA School Programme is administered by MEXT. In 2019 the budget was 231.8 billion JPY (1.49 billion GBP). After that, in response to the expansion of school closures due to COVID-19, the government allocated a further 229.2 billion JPY (1.47 billion GBP), for a total of 461 billion JPY (2.95 billion GBP) in 2019-2020. MEXT's budget request for the 2021 fiscal year included 427 million JPY 2.65 million GBP) for creating online training programmes for teachers in how to use ICT in their lessons. MEXT allocates funding to prefectural and municipal authorities for schools.
Netherlands	21.16 million GBP (25 million euros) 2019-2022	We have not been able to identify funding linked to the digitalisation agenda for primary and secondary schools in the Netherlands. However, the strategic action plan for the Dutch Digitalisation Strategy 2.0 includes subsidies (25 million euros, 21.16 million GBP a year until 2022) for improving the

Country	Amount (GBP conversions are approximate)	Notes
		connection of (senior) vocational secondary education with the labour market, for example for projects that offer training in a profession that has changed as a result of AI.
Norway	No specific funding linked to the strategies	In Norway, the strategy implementation is largely seen as the responsibility of the municipalities through existing funding mechanisms, although there is some central funding for teachers' education and development.
Sweden	No specific funding linked to the strategies	School budgeting in primary and secondary schools is completely decentralised to municipalities in Sweden, which decide how resources will be allocated between schools. The school then has the responsibility of allocating the resources in the best way to meet the needs of students. Neither the digital strategy, nor the subsequent action plan, were accompanied with funding. Some research suggests that this has been a barrier to implementation for some of the policy aims and that schools have had to divert funding from other resources, including staffing, in order to fund the acquisition of hardware.
USA	No specific funding linked to the strategies	The National Education Technology Plan in the USA recommends school districts implement the plan through an unspecified mix of federal programs and reliance on non-profit organisations. However, the federal government does not systematically fund technology in schools, and states vary in terms of the funds they make available for technology in schools. Due to lack of federal and state funds for technology in schools, most states rely on local revenue sources to fund technology in K-12 public schools.

Source: Appendix 1 country reports

Other initiatives to increase the use of digital technology in schools

There is evidence of other initiatives to increase the use of digital technology in the school sectors of the 14 countries. In 12 countries, the investments have been made by central government, however 2 countries (**Estonia** and **Finland**) have sought to attract support from industry.

The key themes of the initiatives include:

- Professional development for teachers, including online training, teacher mentoring, cross-school peer-learning, mechanisms for sharing best practice and ideas, and the development of a Professional Digital Competence Framework for Teachers (**Australia**, **Austria**, **Czech Republic** and **Norway**).
- Improving digital infrastructure (**Ireland and Japan**) and broadband connectivity (**Ireland**, **Italy** and the **USA**).
- Student access to devices (**Estonia**, **Finland** and the **USA**).
- Digital resources for students (**Finland** and **Estonia**) and teachers (**Finland**).
- Activities for students, including computing and coding challenges and summer schools (**Australia**).
- Digital national tests (**Sweden**)
- Tools to support schools to develop digital improvement plans (**Estonia**).
- Leadership development for school principals and ICT leaders for projects to implement a digital education curriculum (**Australia**).
- Classroom innovation, including the use of robotic kits, iPads, fully-equipped computer classes, 3D printers and the development of the Edulab model to make learning more sustainable and evidence-based (**Estonia**).
- Developing partnerships between Science, Technology, Engineering and Mathematics (STEM) professionals and schools to build teachers' and students' understanding of STEM applied in the real world (**Australia**).
- Seeking support for schools from industry, see Case study: IT industry support for schools to improve their use of technology in Estonia (**Estonia** and **Finland**).

- Establishing links between schools and universities to accelerate ICT development (**Japan**).
- Supporting a teacher specialist project, including digital specialists, which aims to recruit and retain the best teachers in the classroom (**Norway**).

Case study: IT industry support for schools to improve their use of technology in Estonia

The switch to distance learning saw a considerable increase in the use of digital platforms, including eSchool, a school management service developed in 2002 and already used by 85% of schools, and E-Schoolbag, developed in 2016, which hosts educational resources quality-reviewed by subject experts (OECD, 2020).

According to Lorenz et al. (2017) the IT industry has supported schools to improve their use of technology, including:

- From 2009 onwards, Microsoft has run several projects under the aegis of their Partners in Learning programme.
- BCS Training has a Creative Classroom project that has been funded by Erasmus+ (amount unknown).
- Samsung Baltics started several projects in Estonia and Latvia from 2014, with the common idea to train six members of the school (including school leaders) who will proceed to innovate the rest of the school and community. Every year, 8–12 schools are chosen for the full training programme and competition where the first prize is 10,000 euros (8,340 GBP). The programmme content and training are provided by Tallinn University experts - professors, lecturers and researchers. At the end of every year, there will be a prize of 10,000 euros for one of the schools
- The SmartLab project that is funded by Estonian Association of Information Technology and Telecommunications runs small-scale projects focusing on robotics, coding and engineering education as extracurricular activities (degree of funding unknown).

As part of efforts to improve the digital competences of the population, Estonia has developed tools to assess the digital skills of students and to evaluate the digital infrastructure of schools. The Foundation Innove worked with researchers from the universities of Tallinn and Tartu to develop digital competency assessments (2019) for students in grades 9 and 12, and those in upper secondary VET. Students receive verbal feedback on their performance, and schools receive feedback on digital competencies at the school level (OECD, 2020).

At the school level, the Digital Mirror, developed in 2018, is a tool used to help schools to assess their digital maturity and develop an improvement plan. Some 449 general education schools were due to complete the self-evaluation process in 2019 (OECD, 2020).

Table 10 summarises approaches/initiatives that are in addition to digital education strategies and plans.

Table 10: Other initiatives to increase the use of digital technology in schools

Country	Description of initiatives
Australia	In Australia, the state is funding a number of projects related to supporting the digital curriculum, including direct grants to schools. The Australian Government, through its National Innovation and Science Agenda (NISA), invested $50.6 million (26.4 million GBP) over four years (1 July 2016 – 30 June 2020) to support Australian teachers and students in implementing the Australian Curriculum: Digital Technologies.
Austria	A school mentoring project in Austria, where schools with experience in the use of digital technology mentored those that did not, with central support and online training. The Mobile Learning project, launched in the autumn of 2015 in cooperation between the Ministry of Education and the Ministry for Transport, Innovation and Technology (BMVIT), is based on a cross-school peer-learning approach and shows how much pupils benefit from the use of digital media. The project was based on the know-how and experience in the eEducation network. Two or three schools with little use of technology in the classroom were mentored by an experienced school to form a regional cluster. Funded by the Federal Chancellery, participating schools were supported by the school of excellence within the Virtual Pedagogical College through a one-year project which also offers training for teachers and Safer Internet workshops in schools for teachers and students. The evaluation of the first round concluded that individual learning is promoted and pupils with different learning profiles worked well on common tasks and in teams. The teachers of the participating schools felt lesson quality increased and saw improved networking and cooperation with the colleagues within their own school and with other schools. Mobile Learning was expanded from February 2017 from 94 schools in 31 clusters to 171 schools in 55 clusters. It is unclear if this initiative is continuing or has been superseded by more recent developments.
Czech Republic	Through the Supporting Capacity Building for Basic Literacies in Pre-primary and Basic Education - Supporting Teaching Practice project (2016-21), with EU financial support, the Czech Republic is

Country	Description of initiatives
	building teachers' capacity to develop students' basic literacies, including digital literacy and computational thinking.
Denmark	Municipalities and schools are encouraged to develop their own digital strategies, adapting national priorities to meet local needs.
Estonia	In Estonia, there are number of initiatives supported by the IT industry including classroom innovation projects. In addition, there are also tools available to help schools assess their digital maturity and develop improvement plans.
Finland	In Finland, the Device for All campaign started in 2015 and encouraged private sector companies to donate laptops to students. The initiative was expanded at the start of the pandemic. Tthe Finnish National Agency for Education (EDUFI) and the Association of Finnish Municipalities identified recipients for laptops. Early in the pandemic, EDUFI collated resources to support online education, and developed an online information hub to guide teachers to adapt normal good practice. Also inspired by the demands of distance learning in the pandemic, a group of Finnish education technology providers launched the website Koulu.me; an open innovation project that offers learning applications for pre-school to secondary education students in a wide range of subjects including maths, science, language learning, and design. Education technology companies provided e-learning materials at no cost to teachers, for an estimated cost of more than 10 million euros (8.5 million GBP), which equates to 15 % of schools' annual total budget for learning materials.
France	In France, in 2018, just over 48 million euros (40.6 million GBP) was allocated to a range of projects in addition to the national education budgetary appropriations. The government announced that additional investments would also be made in subsequent years.
Ireland	In Ireland, it was announced in December 2021 that 50 million euros (42.29m GBP) in grant funding was to be made available for schools to invest in digital infrastructure to support students who are most at risk of educational disadvantage through the digital divide. A further 13.5 million euros (11.42 million GBP) has been allocated to support the delivery of high-speed broadband alongside delivery under the National Broadband Plan. This is in addition to funding provided by the Schools Broadband Programme, through which the Department of Education directly funds the provision of broadband connectivity

Country	Description of initiatives
	to schools at an annual cost of around 13 million euros (10.00 million GBP).
Italy	In 2021, the Italian Government announced that the European Commission had approved, under EU State aid rules, 325 million euros (274.87 million GBP) of public support to connect 12,000 schools in Italy to very high-speed internet by 2025. The scheme aims to promote the deployment of a network able to provide upload and download speeds of 1Gbps to Italian schools.
Japan	In Japan, starting in April 2022, MEXT allocated 1.1 billion JPY (6.4 million GBP) to enable selected primary and lower secondary schools to join the Science Information Network (SINET)[5] to accelerate Japanese schools' ICT development. In 2020, MEXT allocated 0.5 billion JPY (3.1 million GBP) to support empirical studies to identify ways to: (1) effectively utilise cutting-edge technology and establish a diverse communication environment to realize the GIGA School Concept; (2) support municipalities to advance ICT environments.
Netherlands	Currently, the use of digital technology in the schools' sector is guided by the digitalisation agenda for primary and secondary schools, focusing on 5 key themes, which are also included in the the Dutch Digitalisation Strategy 2.0.
Norway	Since 2015, the government has piloted a teacher specialist project, including digital specialists, which aims to recruit and retain the best teachers in the classroom and to strengthen schools as learning communities. In addition, a Professional Digital Competence Framework for Teachers was developed by the Norwegian Centre for ICT in Education and launched in May 2017.
Sweden	The Swedish National Agency for Education (Skolverket) has been tasked by the government to develop digital national tests in compulsory school and upper secondary school from 2017-2022. In January 2019, the Agency published a list of the technical

[5] SINET is the primary Japanese academic network for more than 800 universities and research institutions (see **Information about Sinet**). (United States International Trade Administration, December 2021).

Country	Description of initiatives
	requirements that schools must have in place to fully implement digital national tests by 2022. The objective of the development of digital national tests is to increase pupils' digital skills as well as contribute to ensuring that the national tests and the assessment becomes more robust. The development is carried out in steps until the national tests will be fully digital in 2022. We were unable to find any evidence of funding attached to this initiative so it is assumed that municipalities will be expected to ensure that technical requirements are met through standard funding streams.
USA	The Federal Communications Commission's (FCC's) Emergency Connectivity Fund (ECF) is a $7.17 billion (5.44 billion GBP) programme that will help schools and libraries provide the tools and services their communities need for remote learning during the COVID-19 emergency period. ECF will help provide relief to millions of students, school staff, and library patrons and will help close the Homework Gap for students who currently lack necessary Internet access or the devices they need to connect to classrooms. Congress recently created the Affordable Connectivity Program (ACP), a new long-term $14 billion programme (10.7 billion GBP), which will replace the Emergency Broadband Benefit Program. This investment in broadband affordability will help ensure appropriate connections for work, school, health care and more.

Source: Appendix 1 country reports

Evaluation of cost-effectiveness

There are no studies in the Anglophone literature on the cost effectiveness of digital education strategies and plans, although in 2019 the French Court of Auditors **(**Cour des Comptes), which is responsible for monitoring state spending in France, did recommend that future investments in France should be better linked to teacher training, innovative pedagogies, new pilot projects and use of AI for education (European Commission, 2020). However, broader evaluations of digital education strategies have been undertaken in the **Czech Republic**, **Denmark**, **Estonia**, **Finland**, **Italy**, and (on a smaller scale) **Austria**. These evaluations identify several examples of what has worked well, including:

- stakeholders in the public, private, and non-profit sectors working collaboratively to promote innovation in education (Czech Republic)
- the use of tutor-teachers in training interventions (Finland)

However, findings of the evaluations mainly highlight barriers that impede the implementation of digital education strategies including:

- a lack of financial or human resources, which results in delays (Czech Republic and Finland)
- the lack of systematic strategic and operational planning, especially in systems with high levels of school autonomy (Estonia and Italy)
- the need to improve teachers' digital skills (Denmark, Estonia and Finland) and address variations in teachers' technology usage that occur mainly at the individual level (Finland)
- digital education not being seen as a priority among some stakeholders (Czech Republic)
- a lack of research on the effects of the use of digital technology on learning (Denmark)
- a slow transition of research findings, new learning environments and innovative pedagogical ideas into teaching practices (Finland)

In the **Czech Republic,** the government undertook regular, systematic evaluations of the Digital Education Strategy to 2020 to monitor progress. An interim evaluation in 2019 reported that significant progress had been made in the area of innovation with stakeholders in the public, private, and non-profit sectors working collaboratively to promote innovation in education through forums such as the Digital Coalition (established in 2016). The evaluation analysed data on schools' use of digital technologies and their impact, and found that progress had also been made in providing support for the integration of digital technologies in schools (OECD 2020). According to OECD (2020), the Digital Education Strategy to 2020 had a positive impact on students' digital skills and may have helped facilitate distance learning in the context of the pandemic, where many educational institutions had to move to distance and blended learning approaches. At the same time, the report noted several delays largely due to a lack of financial or human resources and highlighted the important contribution of EU funds. It also highlighted the challenge of digital education not always being seen as a priority among stakeholders (OECD, 2020, 2021).

In **Estonia**, a mid-term evaluation of the Lifelong Learning Strategy, carried out by Praxis (a think tank) and the Estonia Centre for Applied Research (Centar), was published in 2019. The evaluation found significant progress in making digital learning resources more widely available, and in assessing the digital competencies of students and teachers, but identified a need to improve teachers' digital skills. A key recommendation was that strategic and operational planning needed to be better integrated in the next phase of the lifelong learning strategy (OECD, 2020). These recommendations appear to have been taken forward in the aims of Estonia's new learning strategy.

In Denmark, a government publication (Digitalisation with Thought and Vision, March 2019) outlines the current status of the use of technology in schools and the challenges faced. The publication is based on research results, status reports, surveys and workshops with teachers, pupils, headteachers and stakeholders. The research identified a number of challenges including: mixed and limited evidence on the effects of the use of digital technology on learning; teachers (and their trainers) lacking the depth of knowledge to improve pupils' technology comprehension; and GDPR compliance and data ethics (Finn Togo, 2019).

In **Finland,** EDUFI (2018) conducted a survey (2017) to assess the impact of a project involving tutor-teachers supporting their colleagues to make the most of opportunities for the use of technology in their teaching. The survey found that the project had a highly positive impact. In a broader consideration of Finnish digital education strategies, Vahtivuori-Hänninen (Ministry of Education and Culture) identifies as a key challenge a slow transition of research findings into new learning environments and innovative pedagogical ideas into teaching practices (presentation on New Learning Environments and Digitalisation, undated). Through analysis of data collected from two representative samples of Finnish municipalities, Kaarakainen and Saikkonen (2021) concluded that initiatives intended to increase the use of digital technology in education have impacted on the work of some teachers much more than others in terms of the extent to which they incorporate digital technology into their teaching practice.[6] This variation in teachers' technology usage in teaching occurs mainly at the individual level, and only a small proportion of the differences are explained by differences between schools. A report by the European Commission (2019) similarly found considerable improvements in teachers' digital competencies but ongoing disparities in the integration of digital tools in the classroom. Based on the results of their study, Kaarakainen and Saikkonen (2021: 962) concluded that "in-service training should aim in particular to increase [teachers'] digital self-efficacy while improving technology perceptions and ease of use in teaching (for example, in order to encourage teachers to integrate technology into their pedagogical practices)".

In **Italy,** an evaluation conducted after the first year of PNSD highlighted several potential problems, including: the complexity of the implementation programme; the 'parallel' launching of different action plans; and, most importantly, the lack of a comprehensive plan for the training of teachers and school managers who were responsible for implementing PNSD projects (CEDEFOP, 2017). These concerns are echoed in a more recent assessment of the PNSD by Bottino (2020).

In **Austria,** the only evaluation referenced in the literature is that of the Mobile Learning project, the cross-school peer-learning approach mentioned in the previous section, which involves schools with little use of digital technology in the classroom being mentored by an experienced school. The evaluation found that teachers in the participating schools felt lesson quality increased as a result of the project and saw improved networking and cooperation with the colleagues within their own school and with other schools.

Specific decision areas (centralised or devolved) and links to strategies and funding

This section provides an overview of the different types of technology decisions in the countries concerned, whether decisions in these areas are made centrally or devolved, and, if devolved, to what level. We also identify whether these decision areas are accompanied by any specific funding. The country reports provide a greater level of detail on the specifics of initiatives and decisions.

[6] The data analysed by Kaarakainen and Saikkonen (2021) was collected during 2017–2019 for a project called "Comprehensive Schools in the Digital Age"

Broadband and infrastructure

The section on fundamental digital infrastructure above explores wider initiatives for broadband and infrastructure, although clearly schools (and pupils' homes) may well be beneficiaries of these. This section looks at what the countries concerned put in place specifically for schools. Table 11 looks at responsibilities, where they exist, at each level, and identifies any specific funding available.

Table 11: Broadband and infrastructure

Country	Central gov.	Regional/State/Local gov	Schools	Funding
Australia	No specific responsibility.	Broadband connectivity and infrastructure to public schools is a state responsibility.	No specific responsibility.	New South Wales: $328 million (171 million GBP) to upgrade connectivity to all mainland NSW schools. In South Australia, $130 million (70 million GBP) to upgrade internet speed in public schools although it is not clear over what time span this money was spent.
Austria	The federal state has responsibility for all aspects of academic secondary schools. All federal schools should have a high-performance broadband connection based on fibre optics as well as high-performance and sufficient WLAN coverage in the individual classrooms	Municipalities have responsibility for lower secondary and primary schools (compulsory schools), including access to infrastructure.	Much decision making is delegated to schools who are encouraged to develop their own digital strategy to include 'optimising infrastructure'.	The government has also negotiated framework agreements with providers. They offer special conditions for educational institutions, which means that the running costs are kept as low as possible. However, the decision to take

Country	Central gov.	Regional/State/Local gov	Schools	Funding
	Together with local school authorities, the Ministry of Education has developed recommendations for a basic IT infrastructure in schools.			advantage of this is at school level.
Czech Republic	The digital strategy states an ambition of equal access to digital infrastructure in schools.	No specific responsibility.	Schools make technology purchasing decisions but are supported by the 'Profile School 21' portal, a self-evaluation tool that enables schools to determine how successful they have been in incorporating digital technology into school life. 'Profile School 21' focuses on five areas, which include ICT infrastructure.	The government has said it will allocate funds to schools in 2021 – 2023 to ensure they have sufficient digital infrastructure but no figure is available.
Denmark	No specific responsibility.	The central government, regions and municipalities agreed, through the Digital Strategy 2016-2020, to aim at 100 Mbps download and 30 Mbps upload	No specific responsibility.	Funding is largely the responsibility of individual municipalities, with schools funded through a mix of local tax revenues

Country	Central gov.	Regional/State/Local gov	Schools	Funding
		speeds for all households and organisations by 2020. Digital infrastructure within schools is the responsibility of the municipalities.		and government grants. Consequently, there is no information available on national spend.
Estonia	Beginning in 2015 and lasting for five years, a modernisation programme for the physical infrastructure that connects Estonian schools to the internet began. Once completed, schools will have network speeds of at least 1 Gbit/s and full wifi coverage in all classrooms with an ability to increase access speeds as required over the foreseeable future.	For the vast majority of schools, municipalities will have ongoing responsibility for digital infrastructure.	No specific responsibility.	The modernisation programme cost approximately 13 million euros (£10.9 million GBP) allocated from the European Union Social Fund. More generally, municipalities receive central grants to support education.
Finland	No specific responsibility.	Most institutions providing basic and upper secondary level education are maintained by local authorities or joint municipal	No specific responsibility.	Responsibility for educational funding is divided between the State and the local authorities, with municipalities

Country	Central gov.	Regional/State/Local gov	Schools	Funding
		consortia and this is likely to include digital infrastructure.		receiving central grants based on a statutory formula. We could find no specific reference to funding broadband or digital infrastructure in schools.
France	France has invested heavily in digital infrastructure and equipment for schools, with funding weighted towards higher levels of education. As a result, in 2017/2018 there were fewer highly digitally equipped and connected schools at primary level than the EU average (14 % v 35 %), lower secondary was in line with the EU average, and higher secondary level was above it (81 % v 72 %). The Ministry of Education is currently targeting support towards the communities and	No specific responsibility.	No specific responsibility.	We do not have figures for the level of funding.

Country	Central gov.	Regional/State/Local gov	Schools	Funding
	regions with the biggest challenges in accessing digital technology.			
Ireland	The Schools Broadband Programme provides an integrated set of services to schools which includes broadband connectivity.	No specific responsibility.	Schools, supported by direct grant, seem to be responsible for ensuring broadband connection and associated infrastructure. The PDST Technology in Education website states a wireless purchasing framework that had been in place for schools for the last 4 years, and which many schools and Education and Training Boards (ETBs) successfully used to procure wifi, has recently expired. It is not stated if or when a new purchasing framework will be introduced.	13.5 million euros (11.42 million GBP) in grant funding issued directly to schools will be used to supplement delivery of high-speed broadband alongside delivery under Ireland's National Broadband Plan, and commercial provision through the Schools Broadband Programme, through which the Department of Education directly funds the provision of broadband connectivity to schools at an annual cost of around 13 million euros (10.99 million GBP).

Country	Central gov.	Regional/State/Local gov	Schools	Funding
Italy	Since 2015, PNSD (the digital strategy for schools) has included a commitment to broadband connection in every school building.	No specific responsibility.	To receive funding for objectives in the PNSD, with the exception of broadband connection, schools must submit project proposals in open competitions.	The PNSD included 650 million euros (549.73 million GBP) for digital infrastructure, including broadband and wifi connection. In 2021 it was announced that the European Commission had approved, under EU State aid rules, 325 million euros (274.87 million GBP) of public support to connect 12,000 schools in Italy to very high-speed internet by 2025.
Japan	The Japanese GIGA programme is specifically targeted at the development of a national ICT education infrastructure. The main pillar of this aspect of the programme is “cloud by default,” for example the	No specific responsibility.	No specific responsibility.	Support for maintaining the school LAN environment and power supply cabinets (including high schools) 136.7 billion JPY (886.5 million GBP) between 2019 – 2020.

Country	Central gov.	Regional/State/Local gov	Schools	Funding
	establishment of high-speed and large capacity IT network connections to each school. Support for maintaining the school LAN environment and power supply cabinets (including high schools) has been a key element of the GIGA programme			
Netherlands	The digital strategy's education strand has secure, reliable and future-proof infrastructure as a priority. It is intended to promote effective cooperation within the education sector and between the sector and other parties, including the business community, rather than outlining central actions.	No specific responsibility.	School boards (which may be responsible for one or several schools) have a great deal of autonomy over purchasing decisions	A key priority has been IT infrastructure via funding opportunities or joint purchasing of ICT equipment by school boards. The digital strategy does not appear to be accompanied by any funding.
Norway	Norway has a highly decentralised education	No specific responsibility.	Infrastructure is the responsibility of the school	All infrastructure must be funded from the standard

Country	Central gov.	Regional/State/Local gov	Schools	Funding
	system designed purposely to allow decisions to be made at a local level to reflect local contexts and priorities. The digital strategy cites infrastructure as a challenge, although there do not seem to be any planned initiatives to improve the situation within the associated action plan.		owner (municipality for primary and lower secondary; county for upper secondary).	education funding stream and there is therefore no indication of central funding.
Sweden	The digital strategy makes references to the need for appropriate infrastructure and broadband – also needed to conduct the compulsory digital tests.	No specific responsibility.	It is assumed that it would be for the municipalities to work together to achieve the aims of the digital strategy for infrastructure and connectivity. The accompanying Action Plan proposal points to the need to develop common standards and national support for public procurement and technical system evaluation but it is not clear how, and by	School budgeting in primary and secondary schools is completely decentralised to municipalities which decide how resources will be allocated between schools. Research with stakeholders (Gustafsson, 2021) uncovered the view that specific funding might be needed to meet the ambitions of the strategy, although this does not

Country	Central gov.	Regional/State/Local gov	Schools	Funding
			whom, this will be taken forward.	seem to have been forthcoming.
USA	The USA has placed the ICT infrastructure at the heart of its digital education strategy which states that school leaders should recognise the importance of building capacity for creating and maintaining the technology infrastructure. This includes ensuring students and educators have broadband access and adequate wire-less connectivity, with a special focus on equity of access outside of school.	Education is largely the responsibility of states and local school districts. The digital strategy recommends that, as state and local education institutions work to bridge the existing digital divide, they concurrently should be drafting plans for the upgrade of infrastructure necessary to meet the needs of increased user demand as well as speeds necessary for the use of evolving technologies.	No specific responsibility.	Funding is largely the responsibility of the states and systems vary between them. However, national funding was available during the pandemic. The Emergency Connectivity Fund (ECF) helps schools and libraries provide the tools and services their communities need for remote and help close the Homework Gap for students who lack the necessary Internet access or devices they need to connect to classrooms. $7.17 billion (5.3 billion GBP) funding was made available.

Source: Appendix 1 country report

Only **France** and **Japan** have central systems in place for broadband and infrastructure. In **Australia** and the **USA**, decision making is devolved to state level, although in the latter, responsibility is frequently devolved further to school districts. In **Austria**, **Denmark**, **Estonia**, **Finland**, **Norway** and **Sweden**, responsibility for infrastructure falls to the municipalities. Schools themselves have responsibility in the **Czech Republic**, **Ireland**, **Italy** and the **Netherlands**, although school boards may be responsible for more than one school in the latter. School boards in the Netherlands are collaborating to make infrastructure decisions, as detailed in the next case study.

Case study: collaboration between schools to purchase IT infrastructure in the Netherlands

A key priority for the Netherlands has been IT infrastructure via funding opportunities or joint purchasing of ICT equipment. The following activity is highlighted in the Digitization Agenda for Primary and Secondary Education:

School boards collaborate on a secure, reliable and future-proof infrastructure

SIVON is a cooperative association of school boards in primary and secondary education which was established to provide central expertise and to secure a favourable price-quality ratio for school purchasing. Through bulk purchasing and stipulating requirements, SIVON can give schools access to high-quality facilities – more specifically IT facilities – under favourable conditions. School boards that have yet to make a decision on installing sufficiently fast internet can use its services to meet the future-proof internet regulation for primary and secondary education (Ministry of Education, Culture and Science, 2019).

New South Wales and **South Australia** have made funding available to improve connectivity. In South Australia funding for improved connectivity was announce in 2022 but the details of how this will be spent were not available at the time of writing. In the **USA**, some targeted funding is available from central government, largely concerned with bridging the digital divide in low-income families, but otherwise funding is an individual state responsibility. Government funding in **France** has been made available, although weighted towards schools catering for older pupils. The **Czech Republic** Government has said funds will be made available to schools for connectivity. **Japan** has invested in school digital infrastructure as part of its GIGA programme. In **Estonia**, money has been made available through the EU Social Fund.

Funding is the responsibility of the municipalities in **Denmark**, **Finland**, **Norway** and **Sweden**, and they must meet infrastructure costs through normal revenues. In **Italy**, funding is available to schools who submit project proposals in an open competition.

Austria has negotiated a national provider framework to secure more favourable costs, with the association of school boards in the **Netherlands** taking a similar approach. A framework in Ireland to support schools' procurement has recently ended, although the government funds the Schools Broadband programme.

In general, the focus has been on broadband speed and wifi connectivity as a general prerequisite for developing pupils' digital competence and using digital resources and communications. In **Japan**, however, digital infrastructure is linked to its ambitions for Society 5.0 and, in **Italy**, a particular focus has been on creating new physical spaces to allow for new kinds of teaching, as detailed in Case study: STEAM labs in Italian classrooms.

Case study: STEAM labs in Italian classrooms

A key aspect of the National Digital School Plan (PNSD) was the structural investments designed to create new physical places (labs, educational environments and libraries) for technological and methodological innovation.

The enhancement of STE(A)M (Science, Technology, Engineering, Arts, Mathematics) education is one of the elements of the PNSD. The STEAM Lab project equips classrooms with digital infrastructure for experimentation by students at all levels. "We walk the path of wonderful mechanisms" involves primary school children in workshops in which "they design, create and programme objects able to obtain data from the surrounding reality and process them into information ready to be analysed". "Leonardo STEAM Lab" is the path for secondary school students with elements of robotics and coding. Students build – personalising it – a Leonardo machine, documenting the work done. Secondary school students, in "Photographing Science", are challenged to study the birth of the Universe using photographic techniques (STEAM Labs: classes for experimentation Venturella, 2020).

Hardware

This section looks at how the different countries in this report select and finance digital hardware for use in schools. It is clear that, in some of the literature, there is a conflation of digital infrastructure and hardware. It is also the case that, for many countries, purchasing resources of all kinds, including devices, is devolved to local authority or school level, so detailed information is difficult to find. Some digital strategies refer to devices, others do not, perhaps because the country concerned feels this is not a priority because schools already have sufficient access to them. Table 12 sets out information found on hardware in the countries; this usually relates to devices (tablets, laptops etc.)

rather than other sorts of hardware (for example whiteboards) because of the information available in the literature.

Table 12: Hardware

Country	Central gov.	Regional/State/Local gov	Schools	Funding
Australia	No specific responsibility.	The NSW strategy states as an aim that there will be equitable access to digital resources and smart devices but there is no more detail available as yet. For rural, regional and remote schools, a priority of the strategy is that 12,000 teachers in those schools will have access to a portable device and more than 220,000 students will benefit from a higher availability of devices to reach a minimum device-to-student ratio of 1:4. The South Australia digital strategy, through its Digital Guarantee Unit, intends to improve access to devices for students as well as ensure all teachers have a quality device to support their work.	No specific responsibility.	There is no specific allocation of funding to devices in the NSW digital strategy, the aims of which will be supported through the Digital Restart Fund. In February 2022, the government of South Australia announced that $23 million (12 million GBP) of new spending will be invested to improve access to devices for students.
Austria	One of the priorities identified by the Austrian Government in 2020 was Digitalising the	In order to ensure equal opportunities and up-to-date teaching, all secondary school	Schools can apply for the devices through signing up to implement the	Legal guardians of pupils are expected to contribute 25 % of the cost. It is

Country	Central gov.	Regional/State/Local gov	Schools	Funding
	Austrian School, including digital devices for every student.	students should be given access to a digital device under the same conditions. As part of the strategy, the issue of digital devices is planned for the 5th and 6th grade in the 2021/22 school year, and in the 5th grade from the 2022/23 school year.	requirements to become a digital school. The offer also includes devices for teachers. The school chooses the devices. .	unclear what happens in the event that parents and carers are unable or unwilling to contribute. The exact amount of funding available for grants for the purchase of digital equipment is not available.
Czech Republic	Access to technology, which presumably includes hardware, is an aim of the digital strategy.	No specific responsibility.	Schools will take the decision about the purchase of equipment.	The government has said it will allocate funds to schools in 2021 – 2023 for the ongoing renewal of equipment, but no figure is available. Support for purchasing digital equipment for schools has been provided by European funds, although figures are not available.
Denmark	No specific responsibility.	Ensuring schools are able to access appropriate hardware is the responsibility of the municipalities in Denmark.	Danish schools use different strategies:	Funding is largely the responsibility of individual municipalities, with schools funded through a

Country	Central gov.	Regional/State/Local gov	Schools	Funding
			The school provides the students with a device (laptop/tablet) The school provides a number of devices, shared between at least two students BYOD – the students bring their own device with the school or municipality providing a device for those who cannot bring their own.	mix of local tax revenues and government grants. Consequently, there is no information available on national spend.
Estonia	According to the Education Nation website, a 2013 'Survey of schools: ICT in education', by European Schoolnet, found Estonian school students use of their own laptops and mobile devices in education to be above the EU average. In 2014, it was decided that BYOD – bring your own	No specific responsibility.	For students who do not own devices, there's always one set of commonly bought devices in schools. "BYOD is seen as an example of efficient management of resources," according to Estonia Future Classroom Lab's Guide for School	Funding for schools is the responsibility of the municipalities who should take into account in their budget allocations schools' technology requirements.

Country	Central gov.	Regional/State/Local gov	Schools	Funding
	device - would be the Estonian way and there would be no big, country-wide device roll-outs.		Leaders Estonian model. “The schools would like to make more use of technology but existing computer classrooms are insufficient and the schools lack funds to buy mobile devices for all students. Also, any devices purchased need replacing every two or three years. However, most students already own at least one device and, therefore, making educational use of these is seen as sensible. Also, the students are already in the habit of using their smart devices which is helpful.”	
Finland	The Device for All campaign, which started in 2015 and encouraged private sector companies to donate laptops	Finland has a decentralised education system and local authorities and institutions have significant autonomy in	No specific responsibility.	Responsibility for educational funding is divided between the State and the local authorities,

Country	Central gov.	Regional/State/Local gov	Schools	Funding
	to students, was expanded as a result of the pandemic. The National Agency for Education and the Association of Finnish Municipalities identified recipients for laptops.	determining educational provision. Most education-related decisions are taken at municipal or institutional level, with strong stakeholder participation within a relatively loose strategic framework set by central government.		with municipalities receiving central grants based on a statutory formula. We could find no specific reference to funding hardware in schools.
France	As part of the 2015 Digital Education Plan, France deployed a longitudinal assessment of educational digital activities – *ELAINE* – to measure the effects of the distribution of digital equipment on students' skills and on teaching practices and the attitude of teachers towards digital learning. The measurements started in 2018 and 2019; the earliest results are expected in 2021.	The national Directorate of Digital technologies for Education, the regional ICT advisors and the directors of the départements' education services are the key bodies involved in decisions about spending. Local authorities are expected to take account of their surveys and recommendations in making purchasing decisions. The extent to which primary and secondary schools contribute to decisions about spending is not made clear in the Anglophone literature.	No specific responsibility.	We do not have figures for the level of any funding. However, note the section above which indicates that investments in digital infrastructure and technology (which we assume includes hardware) has been weighted towards schools for older cohorts.

Country	Central gov.	Regional/State/Local gov	Schools	Funding
Ireland	The PDST Technology in Education website highlights a PC & Notebook/Laptop Framework, which enables schools to order items from the two listed suppliers, without having to seek quotes from other suppliers. This was made possible because of an Office of Government Procurement (OGP) contract in place with the two approved companies at agreed prices, although this had expired at the time of writing.	No specific responsibility.	The PDST Technology in Education website notes that a Chromebook purchasing framework and an Apple purchasing framework (for Apple Devices/ iPads) that had been in place for schools have recently expired. As in the case of the wireless purchasing framework mentioned above, it is not stated if or when a new purchasing framework will be introduced, but PDST Technology in Education indicate that schools that are considering purchasing Chrome or Apple devices for their school can seek objective advice, including technical advice, from them.	Schools, supported by direct grant, are responsible for the purchasing of devices.

Country	Central gov.	Regional/State/Local gov	Schools	Funding
Italy	The PNSD includes a “bring your own device” (BYOD) policy. BYOD means that students bring their own devices and connect them to the Internet (Wi-Fi) at school.	No specific responsibility.	To receive funding for objectives in the PNSD, with the exception of broadband connection, schools must submit project proposals in open competitions. It is assumed that this could include some hardware, although, given the BYOD policy, hardware may not extend to pupils’ devices.	The PNSD is supported by funding but this does not seem to include an allocation specifically for hardware.
Japan	Japan’s goal of “one device per one student” has been largely reached. As of March 2021 Japan’s Ministry of Education, Culture, Sports, Science and Technology (MEXT) had completed 97.6 % of their planned delivery of hardware devices to 1,769 local governments.	Local governments are responsible for distributing devices to schools.	No specific responsibility.	In 2019 the government allocated 231.8 billion JPY (1.5 billion GBP) for the provision of one ICT device per one student and the integrated preparation of high-speed, high-capacity ICT networks in schools. In 2020, in response to the expansion of school closures due to COVID-

Country	Central gov.	Regional/State/Local gov	Schools	Funding
				19, a further 229.2 billion JPY (1.47 billion GBP) was allocated to the programme.
Netherlands	The digital strategy's education strand does not seem to make specific mention of hardware.	No specific responsibility.	School boards (which may be responsible for one or several schools) have a great deal of autonomy over purchasing decisions. With an estimated market share of seventy percent, Google has become the largest supplier in Dutch primary education. Their market share grew by thirty percent each year between 2016 and 2019, with 170,000 Chromebooks purchased for primary and secondary education in 2018 alone.	A key priority has been IT infrastructure via funding opportunities or joint purchasing of ICT equipment by school boards. The digital strategy does not appear to be accompanied by any funding.
Norway	Hardware is not listed as a priority in the digital strategy.	No specific responsibility.	While central funding was provided in the 1980s and early 1990s to support	All resources, including digital hardware, must be funded from the standard

Country	Central gov.	Regional/State/Local gov	Schools	Funding
			schools' purchase of hardware, this is now a responsibility for school owners (usually the municipalities). In 2019, 83 % of Norwegian students had been provided with their own PC/laptop by their school by the ninth grade, making Norway a leading nation in computer density in an educational context.	education funding stream and there is therefore no recent central funding.
Sweden	The second objective of the digitalisation strategy is equal access to, and usage of, digital tools for all in the school system. A research study (Almén, 2021) found this objective to be a more prominent focus for schools than others, perhaps because of the need for access to digital tools for	No specific responsibility.	By 2015, 75 % of lower secondary school pupils had access to a computer of their own in school. Now it is normal practice that lower and upper secondary schools provide either laptop computers or tablets to their students (Almén, 2021).	School budgeting in primary and secondary schools is completely decentralised to municipalities which decide how resources will be allocated between schools. Schools themselves also make decisions within their allocated budgets, so it is

Country	Central gov.	Regional/State/Local gov	Schools	Funding
	competence to be achieved, but also perhaps because figures like computer per student ratios are more easily measured and compared, potentially important in Sweden's competitive schools' market, in which funding follows students.			not clear who makes the purchasing decision.
USA	The USA, in its digital strategy, includes powerful learning devices as a priority for schools. The NETP states that selecting the appropriate devices depends in large measure on the age of students, their individual learning needs, and the types of learning activities that will be ongoing in the classroom or in after school programmes. It also mentions an instructional	Education is largely the responsibility of states and local school districts. The digital strategy recommends that they should ensure that every student and educator has at least one internet access device and appropriate software and resources for research, communication, multimedia content creation, and collaboration for use in and out of school.	No specific responsibility.	Funding is largely the responsibility of the states and systems vary between them. However, national funding was available during the pandemic. The Emergency Connectivity Fund (ECF) helps schools and libraries provide the tools and services their communities need for remote learning and help close the Homework Gap for students who lack the

Country	Central gov.	Regional/State/Local gov	Schools	Funding
	burden for teachers, who have to manage learning activities while supporting multiple platforms and device types. Activities can also be incompatible with certain devices. Finally, there may be privacy and security issues with regard to the use of personal devices, as they might lack required safeguards.	States and districts should make sure such device purchases are funded sustainably with a plan for device refresh		necessary Internet access or devices they need to connect to classrooms. $7.17 billion (5.3 billion GBP) funding was made available.

Source: Appendix 1 country reports

Hardware (usually devices) is mentioned only in the digital strategies of **New South Wales**, **South Australia**, **Austria**, **France**, **Sweden** and the **USA**. In NSW, the focus is particularly on improving access to devices in rural schools.

Three main approaches to digital devices in schools operate in the countries in this review:

- BYOD – bring your own device – is the main approach in **Estonia** and **Italy**, although for students who do not own devices, there is always one set of commonly bought devices in schools.
- Purchasing digital devices is a school-level responsibility in **Austria**, **Denmark**, the **Czech Republic**, **Ireland**, and the **Netherlands**. In Denmark, practice varies with some schools providing equipment and others operating a BYOD approach, although it is unclear what happens if students in those schools cannot afford devices. Estonia and Italy commonly hold a set of devices in schools for pupils who do not have their own.
- Hardware is a responsibility of local authorities or a state/territory responsibility in **Australia**, **Finland**, **France**, **Japan**, **Norway**, **Sweden** and the **USA**, although it is not always clear to what extent purchasing and decision making is devolved further to school boards/districts or to schools themselves.

In terms of specific funding for devices, this is made available in **South Australia**, **Austria**, the **Czech Republic**, **France**, **Japan** and the **USA**; the latter being a specific response to the pandemic. In Austria, schools can apply for a direct grant although parents and carers are expected to contribute 25 % of the costs; it is not clear how this scheme works in practice. In **France**, funding is weighted to schools catering for older cohorts. **Ireland** and the **Netherlands** both offer support for schools through a purchasing framework in Ireland (although this seems to have expired), and through encouraging joint purchasing by school boards in the Netherlands.

Security

This section includes responsibilities and associated funding for security, including cyber security, in the countries in the review.

Table 13: Security, including cyber security

Country	Measures
Australia	The NSW digital strategy emphasises the security of the internet roll-out. Cyber security seems to be largely the responsibility of states/territories to manage. For example, in 2020-21 plans, the

Country	Measures
	NSW government Customer Service Cluster (how the public interact with government services) committed to investment of $240 million (125 million GBP) over three years through the Digital Restart Fund across the public sector. It is not clear if this involves schools.
Austria	The digital school portal (more details in the interoperability section) that has been set up by the Austrian Government does not collect any information about the user, but offers assistance with daily school administrative processes. Personal data that the portal displays comes from existing applications and is protected. The portal is operated by the Federal Computing Center, which “has the highest standards of data protection and security”.
Czech Republic	The key national body overseeing cybersecurity in the Czech Republic is the National Cyber and Information Security Agency (NCISA), which was established in 2017 to increase the focus on new and emerging threats. One of NCISA’s main areas of activity is to support education in cyber security.
Denmark	The Digital Strategy 2016–2020: A Stronger and More Secure Digital Denmark (an overarching strategy which covers more than education) has in its goals that security and confidence must be in focus at all times, including that the public sector protects data. The Agency for Digitalisation has published the Danish Cyber and Information Security Strategy 2018–2021. To ensure that society can continue to benefit from technological opportunities and that citizens can retain confidence in digital development the government will invest 1.5 billion DKK (168m GBP) in cyber and information security from 2018 to 2021.
Estonia	X-road, the centrally managed distributed Data Exchange Layer between information systems that is the backbone of all Estonia’s e-solutions, offers secure data exchange. The focus on cybersecurity is a prominent feature of the x-road and this can be traced back to the Informatics Council, established in 1990 as many of its members had a connection with the Estonian Academy of Sciences’ Institute of Cybernetics. From this institute, Cybernetica AS, one of the companies that delivers many of the public digital solutions, including x-road, was founded.
Finland	No school-specific information is available but In June 2020, to support the implementation of the Cyber Security Strategy (2019),

Country	Measures
	the government published a resolution on digital security in the public sector that sets out the development principles and key services to be considered to increase resilience in cybersecurity. The 2020-2023 action plan for digital security in public administration describes how the resolution will be put in practice
France	France published a national digital security strategy in 2015 but we could find no education-specific information.
Ireland	PDST Technology in Education, a service which operates under the aegis of the Department of Education and Skills, provides information and advice on cyber security and data security and provides a set of hosted services including anti-virus control and a centralised firewall.
Italy	The digital strategy for schools – PNSD – includes minimum standards for interoperability which may include security standards, but this information is not available in the Anglophone literature.
Japan	According to a recent Mckinsey and company (February 2021) report on the current state of digital in Japan, local privacy regulations pose challenges for cloud learning solutions in schools. Personal information protection ordinances of local governments have been a barrier: local regulations differ by jurisdiction, with the majority prohibiting online access from computer devices that handle personal information. While driven by the desire to protect individuals' privacy, the complexity and multiplicity of such provisions present a major impediment, particularly in implementing remote-based education at scale. MEXT established its first Guidelines for IT Security Policy in Education in 2017 and revised them in May 2021. The revised policy emphasises that local governments/schools should address security measures, including implementation of multi-factor authentication and SSO (single sign on), and the restricting of the connection of students' terminals to school access points only for secure usage.
Netherlands	In 2018, the education sector, supported by the government, drew up a privacy covenant in which they agreed on how to handle students' personal data generated and exchanged through digital learning materials and tests in accordance with the General Data Protection Regulation (GDPR). For instance, the covenant led to agreed-upon rules about the use of pseudonyms to guarantee

Country	Measures
	student privacy in aggregated data, and about data minimisation - the requirement to reduce the number of data attributes in data flows between platforms. The covenant has subsequently been translated into a technical standard, called ECK-iD: a unique and encrypted identification mechanism for students using digital learning materials. In 2018, the National Cyber Security Center (NCSC) published an update to the 2013 National Cyber Security Strategy. Both documents outline the government’s long-term view on cybersecurity and set out concrete actions to combat cyber threats but their provisions are not specific to education.
Norway	The Norwegian architectural framework for interaction, published in June 2018, is intended to help enterprises to define, design, develop and manage digital services and the exchange of data with the public sector. We assume this would cover security aspects. We could find no information on how this might relate to schools specifically.
Sweden	The government established a digitalisation agency in 2018 with the responsibility for coordinating and supporting the use of technology in the public sector with a budget of 102 million Swedish crowns (just over 8 million GBP) in the 2018 Budget Bill. According to the provisions of the bill, these funds should be used to cover the management expenses of the new agency, coordinate and support inter-agency use of technology efforts, the national digital infrastructure and open data. As a result, the use and allocation of financial resources for the development of the digital infrastructure and open data is intended to increase control over high-risk and strategic ICT projects and to align all agencies efforts in updating the IT infrastructure for the public sector. We could find no information on how this might impact on the school sector.
USA	The National Education Technology Plan includes the following recommendations: • Revise practices, policies, and regulations to ensure privacy and information protection while enabling a model of assessment that includes ongoing gathering and sharing of data for continuous improvement of learning and teaching. A key component of this increased capacity should ensure educational leaders have a firm understanding of privacy and

Country	Measures
	security concerns, how those concerns are addressed within the school or system, and clear communication of policies and procedures with all stakeholders. • Include cyber-safety and cybersecurity training for students, teachers and parents as part of district and school Responsible Use Policy training.

Source: Appendix 1 country reports

Not all digital education strategies make reference to data security and few to cyber security. Most of the information on security relates to broader strategies for technology use, such as those for the public sector as a whole, although it is assumed that education would be a part of this. PDST Technology in Education in **Ireland** does offer security advice and services for schools. The **Netherlands**, through a covenant with the education sector, has introduced rules to ensure the privacy of student data. The National Education Technology Plan in the **USA** includes recommendations on privacy, security and cybersecurity.

Case study: cyber security in the Netherlands

The Hague region has established itself as a cybersecurity hub over the past decade. The Dutch government recently established the Global Forum for Cyber Expertise in The Hague, which is already home to Europol's European Cyber Crime Center (EC3) and the NATO Communications and Information (NCI) Agency. It is also home to the Hague Security Delta, the largest security cluster in Europe, in which (cyber) security businesses, government agencies, and knowledge institutions cooperate. In 2018, the National Cyber Security Center (NCSC) published an update to the 2013 National Cyber Security Strategy which outlines the government's long-term view on cybersecurity and sets out concrete actions to combat cyber threats (United States International Trade Administration, 2021).

Data and interoperability

For many of the countries, data sharing and interoperability are facilitated through a single portal access; in some countries, interoperability is often broader than education, encompassing the wider public sector. Table 14 sets out the approaches in the countries in the review.

Table 14: Data and interoperability

Country	Measures
Australia	Interoperability is not specifically mentioned in the digital strategies of NSW or South Australia but the following are suggestive: • The delivery roadmap for the NSW strategy includes platforms for the whole school network and mention of data sharing with parents and the Department of Education being able to provide data-driven insights. • The South Australia strategy aims to improve access to data and platforms.
Austria	The Master Plan for delivery of the digital strategy aimed that, by 2020, uniform platforms and the digital school portal would simplify communication between teachers, learners and legal guardians. As of 2020/2021, a single portal, the Digitale Schule, has become the prime platform for applications and communication between students, teachers and parents.
Czech Republic	Schools are able to choose their own systems and platforms; however, in 2018, the Ministry of Education, Youth and Sports was preparing an interface for communication with school information systems in order to simplify the collection of statistical reports, data and other information within the education sector. It is not clear if this is now operational.
Denmark	The Digital Strategy 2016-2020 states that there will be efforts to support the implementation of the agreement that pupils, parents, teachers and child carers have a shared user portal. The 2012 – 2017 Digital Strategy for Schools sets out a responsibility for all public infrastructure to have a single sign-on solution, with the municipalities responsible for developing a cooperation platform for schools (Aula). The latter was made available to all schools from August 2019. Uni-Login is the digital infrastructure that connects pupils, teachers, parents, the school and digital learning resources.
Estonia	The Estonian e-government infrastructure and its success rest on two main pillars, both introduced in 2001, which create a digital state and digital citizens: the data infrastructure x-road and a compulsory national digital ID. X-road is an interoperability platform for existing decentralised databases and a data exchange layer that can be used by public and private sector actors. It is independent of platforms and architectures, and provides secure interoperability for data exchanges and identification of trusted

Country	Measures
	actors in digital service delivery. The digital ID makes it possible for citizens to be identified digitally and to use digital signatures.
Finland	There does not seem to be an online portal or data sharing platforms in common use, perhaps because of the highly decentralised nature of education in Finland.
France	School data collection and links with new stakeholders outside the school underpin the digital strategy although more details of what this involves is not available in the Anglophone literature. Educonnect is a system for parents and students that allows access to the Ministry of Education’s portal, FranceConnect to carry out online administrative procedures.
Ireland	We could find no information on this in the literature; this may be because of the devolved nature of technology decisions.
Italy	A core aim of the Digital Italy 2026 Plan is to make all public data interoperable, which also aims to provide 70% of Italians with a unique digital identity by 2026. Digital identity will become the main tool to access all public services. The digital strategy for schools lists minimum standards for interoperability as a priority.
Japan	Priorities of the GIGA programme included systems to standardise educational data collection. The Ministry of Education is looking to develop a “smart school scheme,” in which all the academic and administrative data can be more effectively utilised to help students, teachers and parents. However, this ambition may be hampered by local regulations regarding personal information on computer devices which vary between regional jurisdictions.
Netherlands	The privacy covenant agreed on how to handle students’ personal data generated and exchanged through digital learning materials and tests in accordance with the General Data Protection Regulation (GDPR). For instance, the covenant led to agreed-upon rules such as the requirement to reduce the number of data attributes in data flows between platforms. The covenant has subsequently been translated into a technical standard, called ECK-iD: a unique and encrypted identification mechanism for students using digital learning materials. ECK-iD authenticates users logging into Basispoort, a system which facilitates the exchange of learning data and results between various networked

Country	Measures
	digital learning platforms and online management systems, while protecting a student's identity from data mining.
Norway	The Norwegian architectural framework for interaction, published in June 2018, is intended to help enterprises to define, design, develop and manage digital services and the exchange of data with the public sector. The framework provides access to a common toolbox that contains principles, concept definitions, models and guidelines for digital interaction. It contributes to increased interoperability and interaction ability in the development of digital solutions although there is no reference to schools specifically. Feide – joint electronic identity – is the preferred solution for secure identification in the education sector, chosen by the Norwegian Ministry of Education and Research. With Feide, students and staff have access to a wide variety of services related to research and education using just one username and password. Feide is available to all schools in the Norwegian primary and secondary education.
Sweden	In Sweden, the strategy makes references to the need for appropriate infrastructure, hardware and broadband, and systems that have interoperability. The Action Plan developed by local authorities points to the need to develop common standards and national support for public procurement and technical system evaluation. National single sign-on solutions are also in the Action Plan as an aim. However, it is not clear from the literature if there are detailed plans for these proposals or if they have been taken forward as yet.
USA	In the USA, the Education Blockchain initiative, launched by the Office of Educational Technology in partnership with the American Council on Education in February 2020, explores novel applications of distributed ledger technologies like blockchain to address complex challenges in education. This initiative focuses particular attention on understanding how blockchain technology can facilitate the secure, traceable, and verifiable exchange of educational data among institutions in the learning and employment ecosystem.

Source: Appendix 1 country reports

Single sign-on solutions are available in some countries – **Austria**, **Denmark**, **Estonia**, **France**, the **Netherlands** and **Norwa**y and proposed or in development in others – **Italy** and **Sweden**. Both the digital strategies for schools in **New South Wales** and **South Australia** aim to improve data sharing and platforms, but without detailed plans as yet. **Ireland**, again with decision making largely devolved to schools, does not seem to have any plans in this area. The **USA** is exploring how novel applications of distributed ledger technologies like blockchain can facilitate data exchange. Ambitions for increased interoperability and data sharing seem to have been hampered by, in the case of **Japan**, local privacy laws, and, in **Sweden**, by the decentralised nature of the system.

Case study: organisations responsible for interoperability in Denmark

The Centre for Technology and Data is responsible for preparing, coordinating and implementing work on data (for example by providing an improved framework for sharing and reusing data) and new technology in the public sector. This includes ensuring interoperability between work on basic data and common public sector digital architecture. The Centre is also responsible for a number of initiatives based on the common public sector Digital Strategy 2016-2020 and the Coherency Reform track towards world-class digital service. This includes common public sector digital architecture, the Basic Data programme, and strategies for data and AI.

The Danish Agency for IT and Learning (STIL) develops and operates common IT infrastructure such as UNI-Login and STIL's integration platform. Common public standards set by require that the Agency must ensure easy and secure access to the school's digital solutions, exchange data between IT systems and ensure good competition in the IT market for IT solutions for primary and lower secondary schools.

The parts of the joint public infrastructure that the individual school comes closest to are an expansion of the UNI-Login function as well as an integration platform that enables the use of data from the Ministry's national services in the municipal learning platforms and the collaboration platform, Aula. The association of municipalities (KL) and the municipalities' IT community, KOMBIT, are responsible for the programme management of Aula.

Back office and management information systems

This section explores the approach taken to information management in schools (MIS). This often links with the section above on interoperability, which frequently involves single sign-on solutions, and explores the functionality of the software linked to this and how the systems allow schools to manage and share information with stakeholders.

Table 15: Back-office and information systems

Country	Systems and functionality
Australia	South Australia is funding an Education Management System for all schools to track student records and access to an information portal for parents/carers.
Austria	Austria’s central portal is designed as a single sign-in access for schools, pupils and parents. The portal was set up by the Austrian Government and is operated by the Federal Computing Center. Right from the start, the aim was to bundle existing applications in order to provide teachers, learners and their legal guardians with consolidated and clear information in an easy-to-use manner and to provide support in everyday school life in different ways. It does not collect any information about the user, but offers assistance with daily school administrative processes. In a first step, the electronic class register WebUntis, the learning platforms LMS.at and Moodle-Eduvidual, Sokrates Bund and the content portals Eduthek and Edutube were connected to the portal. A search function for learning content offers quick access to numerous exercise materials and learning videos. The portal has been made available free of charge to all teachers and students at federal schools since September 2020 and access to legal guardians provided from December 2020.
Czech Republic	School information systems are used by almost all Czech primary, secondary and tertiary professional schools. The systems are used both for pedagogical and administrative purposes, as well as to communicate with pupils and their parents. The Ministry of Education, Youth and Sports is preparing an interface for communication with school information systems in order to simplify the collection of statistical reports, data and other information within the education sector.
Denmark	Uni-Login is the digital infrastructure that connects pupils, teachers, parents, the school and digital learning resources in Denmark, funded by central government. It provides access to almost all digital resources in the school: • Digital learning resources • The school’s intranet

Country	Systems and functionality
	• Internet and Cloud services • The school's computers and wifi. Procurement of access to Uni-Login is the responsibility of the municipality for primary and lower secondary schools. Aula is a communication platform between schools and parents and carers. While a description of full functionality is not available in English, the platform is intended to offer: • A user-friendly one stop communication platform for all, set up to add future innovative features • Easy access to personalised information and overviews • A uniform system across institutions and all 98 Danish municipalities • Reliable data processing and a strong foundation for local authorities' data protection measures The solution encourages competition and transparency for providers of learning platforms and educational apps through integration to Aula. Information systems seem to be largely a matter for schools/municipalities excepting where some aspects may be covered through Uni-Login and Aula.
Estonia	One of Estonia's design principles is to build in interoperability rather than seeking to create unified databases and information systems. HarID is a personal information and user account management system designed for educational institutions in Estonia and is suitable for the administration of user accounts and integration with existing systems. Ninety-five % of schools use e-school solutions that allow parents, teachers and children to collaborate and organise all the information necessary for teaching and learning.
Finland	The decentralised approach, in which technology decisions are largely made and funded at a local level, means that there is little evidence in the Anglophone literature concerning the central funding or mandating of any particular tools, systems or software.
France	EduConnect is designed to simplify and accelerate the administrative procedures required of parents and give them, in

Country	Systems and functionality
	real time, more extensive and complete information on the education of their children, while bringing parents and teachers into closer contact. It aims to address all the legal guardians of pupils in primary school, middle school and high school, and ultimately all pupils, to enable them to access online services related to education. The EduConnect account allows access to: the Ministry's Education Services portal to carry out online procedures (such as applications for scholarships and registration); to consult school reports and school records; and to access a digital work space. We could find no information on any centrally used management information systems.
Ireland	We could find no information on this in the literature; this may be because of the devolved nature of technology decisions.
Italy	We could find no relevant information in the Anglophone literature.
Japan	The Ministry of Education (MEXT) is looking to develop a “smart school scheme,” in which all the academic and administrative data can be more effectively utilised to help students, teachers and parents. MEXT highlights the importance of building an ICT system for education to: • Enhance the benefits of ICT by developing and verifying prototypes for online learning systems that will ensure learning as well as standardising educational data, including the codification of the National Curriculum Standards. • Reduce the burden of preparing classes and students’ assessments for teachers, and promote integrated support systems for school administration.
Netherlands	The Basispoort Foundation is a partnership between four major educational publishers and three school suppliers. It provides a single sign-on access to the products of approximately 30 publishers, network providers and suppliers of school administration packages. It enables students, teachers and support staff of primary schools to access teaching material and

Country	Systems and functionality
	software packages of the affiliated publishers, provided the school has a license.
Norway	Feide – joint electronic identity – is the preferred solution for secure identification in the education sector, chosen by the Norwegian Ministry of Education and Research. With Feide, students and staff have access to a wide variety of services related to research and education using just one username and password. The Feide platform hosts a number of third- party digital products including learning resources and administrative software; some are free but most seem to require schools to pay (at least for full functionality). Feide is available to all primary and secondary schools.
Sweden	Single sign-on solutions that make it possible to access all available digital learning resources on the school's network without additional logins as well as a better overview of available educational content and more flexible licensing solutions are in the Action Plan in Sweden. However, it is not clear if and how this will be coordinated at a national level.
USA	The National Education Technology Plan recommends that States, districts, and others should design, develop, and implement learning dashboards, response systems, and communication pathways that give students, educators, families, and other stakeholders timely and actionable feedback about student learning to improve achievement and instructional practices. The next generation of such tools should integrate across platforms and tools seamlessly. "Although current products and dashboards include basic functionality and features that improve on those of their predecessors, future iterations should be built on a premise of feedback and conversation, allowing learners and families to discuss learning outcomes and evidence and increasing agency and ownership across stakeholder groups" (Department of Education of the United States, 2017)

Source: Appendix 1 country reports

For **South Australia**, **Austria**, **Denmark**, **Estonia** and **France**, solutions enable parents and carers to interact with the education system in myriad ways to support and understand their children's education. Evidence of nationwide single business administration systems are less common, with a more frequent approach being to facilitate the access of different information systems through a single interface. For **New South Wales**, **Finland**, **Ireland** and **Italy** we could find no information on approaches, while in the **Czech Republic**, **Japan**, **Sweden** and the **USA**, there are ambitions in this area but no implementation details found in the literature.

Case study: education management system in South Australia

The South Australian Department for Education announced in September 2018 a new Education Management System (EMS), a student-centred online service for public schools and pre-schools. Key features of the EMS include:

- a single student record that captures all the relevant information about a child's progress in the public education system
- easier recording of enrolments, family information and movement between schools
- a teacher toolkit to make it simpler to record attendance, behaviour management, prepare reports, plan and communicate
- high quality timetabling and scheduling tools
- learning management system to make it easier to track and report on student learning, homework and assignments
- financial management tools to support budgeting, invoicing and procurement
- parent/caregiver portal with 24-hour access to timetables, homework, notifications, events, attendance and achievement
- school administration tools to support site and facilities management
- business analytics to provide teachers, principals, education directors and the department with reports and data to support and guide decision making

This digital schools' management solution will be rolled out across the state's 900-plus public schools by Civica in partnership with Frog Education and EdSmart, with a ten-year roll out at a cost of the system at $82.3 million (43 million GBP).

Curriculum content

This section looks at how the countries in the review develop the digital skills of students. Curriculum reforms to strengthen digital competence are sometimes part of a digital strategy and, in other cases, sit outside of it. Even where curriculum development is not part of the digital strategy, objectives often reference the curriculum or include initiatives designed to support the implementation of the curriculum. In the majority of countries, even where much decision making in schools is decentralised, it is generally the case that the overarching curriculum is set at a national level (in the **USA** it is the responsibility of the states; this was also true of **Australia** until recently, when a national curriculum was introduced). By setting digital competences in the curriculum (and, usually, tests and qualifications based on the curriculum), national governments retain a degree of leverage over what is taught and assessed and, therefore, influence decisions on teacher CPD and the selection of classroom resources, even where such matters are devolved.

In 2016, the European Parliament and the European Council adopted a Recommendation[7] on the Eight Key Competences for Lifelong Learning, which young people ought to have acquired at the end of the compulsory education and training period – and as adults during their life – through formal, informal and non-formal learning opportunities. Digital competence (i.e. the confident and critical use of Information and Communication Technologies at work, recreationally and in communication) is one of those eight key competences. This recommendation is likely to have influenced curriculum development in EU member states.

The country reports provide considerable detail of content and approaches to developing curricula but these are summarised in table 16.

Table 16: Curriculum content

Country	Summary description
Australia	In Australia, 'digital skills' is a subject in the curriculum. In addition, ICT also one of the cross-cutting 'capabilities' that are reflected in subject content for other curriculum subjects (see section on curriculum).
Austria	Digital competences expected at each school stage are set out in the Austrian curriculum and measured through testing.
Czech Republic	The Czech Republic's Digital Strategy to 2020 aimed to promote new approaches to teaching and learning through the use of digital technologies, to improve students' digital competencies, and to develop students' knowledge of information technologies. It is not clear from the Anglophone literature if and how this has affected the curriculum.
Denmark	In Denmark a general upper secondary reform introduced digital competencies in all relevant subject curricula in general upper secondary educations from the school year 2017/18. A four-year test programme, running until 2021 with 40-50 participating secondary schools, aimed to develop learning in programming (computational thinking), consequences of

[7] Recommendation 2006/962/EC on the Key Competences for Lifelong Learning

Country	Summary description
	technology and automation on society, design and innovation, problem solving, digital competencies (i.e., social media).
Estonia	The Estonian national curriculum emphasises the development of digital competences. It is one of the eight key competences that the schools are required to focus on. The assessment criteria included in the learner model describe what the learner needs to know by the end of each school level.
Finland	In Finland, the new national curriculum implemented from 2016 requires schools to integrate and apply ICT and digital skills in all school subjects without teaching ICT as a separate school subject.
France	Since the introduction of the Digital Strategy Plan for schools in 2015, digital technology has been present in all school curricula in France from primary to upper secondary.
Ireland	The Digital Strategy instigated a programme of curriculum reform which sees digital technologies embedded in curriculum specifications in each subject which should include opportunities to use technology and digital media tools to learn and communicate at all levels.
Italy	The Italian National Plan for Digital Schools 2015-2020 included a specific action devoted to programming as a way of bringing computational and logical thinking to all students. The main rationale for introducing computational thinking is to foster twenty-first century skills and to move students from being passive users to active producers of technologies. While it is still unclear how the Ministry will reform the current curriculum guidelines to include computational thinking, the government is committed to finalising it by 2022.
Japan	MEXT revised the National Curriculum Standards for elementary and lower secondary schools in March 2017 for introduction in 2018 and for upper secondary schools in March 2018 for introduction in 2020. Changes are designed to equip pupils with the knowledge, skills and understanding to thrive in a world of rapid progress in AI and technology.
Netherlands	The Netherlands has updated the curriculum to increase digital literacy in primary and secondary education.

Country	Summary description
Norway	ICT is implemented in the curriculum as one of five basic skills: oral, reading, writing, numeracy and digital skills. A framework describes how these basic skills function at different levels, covering compulsory and secondary education. The framework divides the digital skills into four sub-categories: 1) searching and processing, 2) producing, 3) communicating, 4) digital judgment. Basic skills are cross-cutting – that is they are part of all subjects, rather than subjects in their own right – with related targets in each subject.
Sweden	In Sweden, recent revisions to the curriculum strengthen digital skills. In addition, from 2017, programming was introduced to mathematics at all school levels.
USA	Curriculum content is the responsibility of the individual State.

Source: Appendix 1 country reports

While all countries for which we have information have taken steps in recent years to strengthen the development of digital skills in their curricula, increasingly countries are doing so through embedding the use of digital technologies in other curriculum subjects instead of, or as well as, having ICT as a subject in its own right.

Case study: digital technology and ICT capability in the Australian curriculum

The Technologies subject area within the curriculum provides students with the opportunity to learn about and work with traditional, contemporary and emerging technologies within two distinct but related subjects: Design and Technologies, and Digital Technologies.

In the Design and Technologies curriculum, students create solutions across a range of technologies contexts. Students consider the economic, environmental and social impacts of technological change and how the choice and use of technologies may contribute to a sustainable future. Students also take into account the ethical, legal, aesthetic and functional factors that inform the design processes.

In Digital Technologies, students purposefully use computational thinking and information systems to define, design, implement and evaluate digital solutions. In addition to subject specific content, the curriculum also describes 'general capabilities' which are represented to varying degrees across the subject areas. The ICT capability involves students developing knowledge, skills and behaviours that enable them to responsibly use ICT tools associated with: information access and management, information creation and presentation, problem solving, decision making, communication, and creative expression

Programming skills have also been introduced to the curricula in **Denmark**, **Norway** and **Sweden**.

Case study: programming introduced to the curriculum in Norway

Beginning with the school year 2016/17, a three-year pilot introducing programming as an optional subject was implemented in a number of secondary schools in Norway. However, by 2018, the government decided to introduce programming as a permanent elective subject from 2019, and to start trials of programming and modelling in upper secondary school as well, without waiting for completion of the pilot.

Curriculum support and resources

Many of the countries in this review provide access to curriculum resources such as materials, apps and lesson plans, either through central portals with other functionality (see the section on back office and management information systems above) or as a separate database. In some instances, these are managed and run by central government; in others, they are a resource developed outside of government. In some cases, all resources are free; in others, access is paid for by subscription or databases links to a mix of free or paid-for resources. Some countries also provide other initiatives to support the implementation of the curriculum, such as pupil workshops. Table 17 sets out the approaches in different countries.

Table 17: Curriculum support

Country	Description	Funding
Australia	To support the implementation of the Australian Curriculum: Digital Technologies; the central government funded support for: • Grants to school principals and Information and Communication Technology (ICT) leaders for projects to implement the Australian Curriculum: Digital Technologies through a whole of school approach; • Online professional development courses for teachers through expansion of the University of Adelaide's Digital Technologies Massive Open Online Courses (MOOCs); • Online computing challenges for all Year 5 and Year 7 students (aligned with Australian Curriculum: Digital Technologies) that provide structured teaching and learning modules to support the curriculum;	The Australian Government, through its National Innovation and Science Agenda (NISA), invested 50.6 million dollars (26.4 million GBP) over four years (1 July 2016 – 30 June 2020). The Grants to Schools element of the offer saw the government commit 4 million dollars (just over 2million GBP) over 2 years (1 July 2016 – 30 June 2018) to provide schools with grants for projects, that will encourage, facilitate and inspire the effective implementation of the Australian Curriculum: Digital Technologies on a whole of school basis. Schools applied to the government for grants.

Country	Description	Funding
	• ICT summer schools to engage Year 9 and 10 students, with a focus on those from disadvantaged backgrounds, to increase their participation in digital technologies and STEM studies in school, post-secondary school and the workforce; • Cracking the Code - a series of fun and engaging computing and coding challenges and activities for school students, to be held in National Literacy and Numeracy Week; • Teacher support for digital technologies to provide in-class support and/or telepresence support and follow-up to schools in the early stages of implementing the Australian Curriculum: Digital Technologies; and • Developing effective partnerships between Science, Technology, Engineering and Mathematics (STEM) professionals and schools to build teachers' and students' understanding of STEM applied in the real world. The Digital Technologies Hub is an online portal that supports implementation of the digital technology aspects of the Australian Curriculum. The Digital Technologies Hub was developed by Education Services Australia for the Australian Government	

Country	Description	Funding
	Department of Education, Skills and Employment. It includes learning resources and activities for students and teachers to build their digital capability. It also supports school leaders to develop a whole school plan. In addition, families can find resources to help them support children to develop skills and plan a career. As well as free resources, it also links to a range of commercially available resources (software and hardware).	
Austria	The digital platform Eduthek provides in-depth exercise materials for all types of schools and subjects. The Eduthek bundles content using a uniform catalogue system and makes it available to teachers and students with an overarching metadata research and full-text search. It offers clearly prepared learning and exercise material for schoolchildren of all school levels to practice at home and to deepen learning material. In the ongoing expansion of the Eduthek, all digital teaching and learning resources will be aligned with the curriculum. This means that the digitally prepared curricula and the fields of competence to be acquired can be efficiently linked with the digital teaching and learning materials and the content offers for daily teaching can be researched even better. The Eduthek is linked to the digital school portal.	Eduthek is developed and funded by the Federal Ministry of Education, Science and Research. The Foundation for Innovation in Education 2017, which focuses in particular on the topics of digital education and accelerating EduTech, was endowed with 50 million euros (41.8 million GBP) in 2017. In 2020, the Austrian Government announced funding of 250 million euros (208.7 million GBP) by 2024 to support the implementation of the Digital Master Plan. No Anglophone information could be found for the details of this funding but it seems most likely, given the autonomy of school decision making and the details of the central offer, that the funding is largely intended to develop central offers of resources, training and support, including Eduthek.

Country	Description	Funding
	A seal of approval for materials has been introduced by the government for apps for mobile learning as well as for use in blended and distance learning. The seal of approval is intended to provide parents, teachers and schoolchildren with orientation and assistance in the selection of innovative products that are already on the market.	
Czech Republic	The digital learning strand of education policy states that teachers and pupils will be assisted by digital tools for the individual assessment of learning outcomes, as well as for self-assessment. The government will support platforms that enable pupils to gain greater learning autonomy, as well as the individualised development of their potential. The information and data generated by the new tools will be used to evaluate school curricula (i.e. the achievement of learning outcomes) and as a source of information on the training needs of teachers (i.e. a basis for further training to support the achievement of better learning outcomes). In 2012, the Czech Republic established a free online portal for educators (The National Methodological Portal), supervised by the National Pedagogical Institute (NPI), which aims to support schools/teachers in implementing curricular reform by providing a virtual space for sharing educational materials, texts, ideas,	While the central portal is developed and funded by central government, the level of funding is not available in the Anglophone literature.

Country	Description	Funding
	expert discussion, online teacher training courses, etc.	
Denmark	Uni-Login is the digital infrastructure that connects pupils, teachers, parents, the school and digital learning resources in Denmark, funded by central government. It provides access to almost all digital resources in the school including digital learning resources. In addition, the Materials Platform, developed and maintained by the Agency for IT and Learning, is a national online catalogue that contains descriptions of all types of teaching aids for use in the education sector including both analogue and digital materials. The materials can be purchased or picked up free of charge directly from the individual publisher or manufacturer. This means that, although the platform was developed centrally, the materials it links to may be free to schools or may need to be paid for.	Uni-Login and the Materials Platform are developed and funded by central government and its agencies. No information on the level of funding for these initiatives is available. Between 2012 and 2017, DKK 500m (Approx. 56m GBP) of government funding was provided to support digitisation in primary and lower secondary schools and this was primarily spent on supporting municipalities' investments in digital learning resources (50 % of cost) and research. It is not clear what the definition of 'learning resources' includes. Procurement of access to Uni-Login is the responsibility of the municipality for primary and lower secondary schools.
Estonia	As part of efforts to improve the digital competences of the population, Estonia has developed tools to assess the digital skills of students and to evaluate the digital infrastructure of schools. The Foundation Innove worked with researchers from the universities of Tallinn and Tartu to develop digital competency assessments (2019) for students in grades 9 and 12, and those in upper secondary VET.	Because of the diffuse nature of the use of digital technology in Estonia over the last thirty years, the involvement of private sector funding and that education was seen as part of a much broader process of transformation, it has not been possible to identify funding related to particular strategies. It is not clear how, and by whom, many of the tools and applications listed were developed and funded and whether schools' access to

Country	Description	Funding
	Estonia also provides an environment for conducting national and school-based exams in an electronic format. E-Tests and the e-Assessment database EIS is linked to the Estonian Education Information system and data exchange platform X-Road. eKool is an easily accessible web-based school management tool bringing together students and their families, schools and supervisory bodies. Stuudium is a suite of online apps for schools that connects teachers, parents and students. Study materials, information about academic progress and simple messaging are accessible in one online environment. State-provided E-schoolbag – the portal for digital learning materials – helps to find the educational materials located in different digital tools. The search engine contains materials for basic, general and vocational education. Privately owned OPIQ provides digital textbooks for all study levels and all subjects. Many schools in Estonia use the e-learning environment Moodle for lessons and information exchange. The Education and Youth Board of Estonia offers Moodle free of charge to general and vocational schools in Estonia. In 2012 Estonia launched the ProgeTiger programme, which aims to improve the technological literacy	them is free. However, Education Nation website says that the tools are typically co-created between schools, universities, and companies. It is not clear in the literature how the ProgeTiger programme is funded and implemented.

Country	Description	Funding
	of teachers and students. A variety of courses and training have been undertaken to this end, including programming, robotics and computer hobby groups, which have proved to be very popular.	
Finland	Experiments with Digital Learning encompasses innovations in pedagogy, digital learning and new learning environments. The National Board of Education hosts a 'Centre for Innovations' to coordinate the experiments and to ensure the efficient dissemination of best practices. As a response to the pandemic, the Finnish National Agency for Education (EDUFI) collated resources to support online education, and developed an online information hub to guide teachers to adapt normal good practice. Also inspired by the demands of distance learning in the pandemic, a group of Finnish education technology providers launched the website Koulu.me; an open innovation project that offers learning applications for pre-school to secondary education students in a wide range of subjects including maths, science, language learning and design.	40 million (33.5 million GBP) was provided from central government between 2016 and 2019 to support the Experiments with Digital Learning comprehensive action plan. Education technology companies provided e-learning materials through Koulu.me at no cost to teachers, for an estimated cost of more than 10 million euros (8.5 million GBP), which equates to 15 % of schools' annual total budget for learning materials.
France	A core component of France's current digital strategy for schools is the creation of a digital resource bank. This seems to be proceeding on a subject-by-subject basis.	The investment programme for 2018-2019 included funding of 3 million euros (2.54 million GBP) for the development of three new digital resource banks for schools for languages and cultures of

Country	Description	Funding
	Pix is a free online public service to assess, develop and certify digital competences for pupils, higher education (HE) students and workers was set up. Since 2019, secondary students in France have had access to the Pix tools through their school's digital learning platform to regularly test their digital skills and to achieve certification, based on the EU’s Digital Competence framework (DigComp). Homework done is an online tool created by the French National Center of Distance Education (CNED), which offers instant help on lower secondary-school skills, as well methodological support, allowing students to become more autonomous when doing their homework. The D’COL platform supports students in priority zones in mathematics in fourth to sixth grades and provides unlimited access to personalised assistance. The School, Digital, Industry (ÉNI) project aims to create a platform of digital educational resources that promote industry. Developed in partnership with industry, it offers digital resources for professional and technological education to support career guidance and better preparation for the workplace. OpenENT is used by 2 million pupils and students in France at more than 1,700 schools. “monLycée.net”, “Paris Classe Numérique” and “lyceeconnecte.fr”	Antiquity, modern languages and French. France has invested strongly in digital platforms for education and training in recent years but the cost of digital platforms listed is not available.

Country	Description	Funding
	are all digital workspaces based on OpenENT. They operate as a social network dedicated to education that is 100 % secure and under the control of the school. OpenENT enables a circle of trust between pupils, parents and teaching staff while contributing to the continuity of teaching.	
Ireland	An online repository of teaching resources (Scoilnet) supports teachers in sharing and finding useful resources for the classroom. In addition to free resources, Scoilnet also offers services including: • Content for schools, i.e., content that has been licensed or made available to schools within the Schools Broadband Network, for example, World Book Online, Irish Newspaper Archive, Irish Times Digital Archive, Dictionary of Irish Biography and JSTOR Ireland Collection; • Scoilnet websites, i.e., a range of independent websites produced and managed by Scoilnet that focus on specific curriculum subjects; • Scoilnet accounts, i.e., one single account for teachers that can be used to access all Scoilnet services as well as some external services; and • Scoilnet webhosting/blogs, i.e., a managed service for schools wishing to create or host a school website.	Scoilnet is the Department of Education and Skills (DES) official portal for Irish education. Originally launched in 1998, the website is managed by PDST Technology in Education on behalf of the DES. Scoilnet collaborates with practising teachers to maintain and manage the content on the website. Any registered teacher is able to register with Scoilnet to access resources and services. We are unable to find funding figures for this service.

Country	Description	Funding
Italy	The digital strategy for schools includes, as a priority, the promotion of open educational resources.	The OER-related action, which aims at building a system of rights and licenses that is sensible and functional for OER, was not equipped with a dedicated budget and should have started in 2016 mainly through local projects to be developed within schools. Unfortunately, to date just a limited number of these projects have started (Nascimbeni, 2020).
Japan	During school closures due to covid between March 2020 and June 2020, MEXT launched an online platform (Children's Learning Support website) and provided online educational content. The portal site includes learning content for students from preschool to high school (videos, audio files, downloadable workbooks, useful links, materials for teachers). The content was collected from various sources, both from government sources and private sources (for example, publishing companies, private education companies, educationTV channels, museums). The content is organised by subject and by grade, but also organised by topic (for example, how to make face masks). Though schools reopened in June, the portal continues to evolve with new content being added regularly.). In conjunction with the next revision of textbooks in 2024, MEXT aims to implement "digital textbooks" at all elementary schools in Japan.	No information on funding.

Country	Description	Funding
Netherlands	The Netherlands is committed to private-public partnerships and fostering healthy market forces to improve resources.	We have not been able to find specific funding allocated to this.
Norway	The Action Plan for Digitalisation in the Primary and Secondary Education and Training proposes cooperation on access to digital learning resources. This covers the standardisation of services and access points, such as a service catalogue of digital learning resources with developing and piloting a portal which categorises resources to enable easy selection by teachers. There is also an intention to make the online catalogue or portal stimulate competition among providers of digital resources. However, a number of different approaches, including centrally developed resources, currently exist. More information is provided below.	There is no allocated funding from central government for this. It is for the municipalities to take forward the Action Plan, presumably from existing funding.
Sweden	Single sign-on solutions that make it possible to access all available digital learning resources on the school's network without additional logins, as well as a better overview of available educational content and more flexible licensing solutions are in the Action Plan in Sweden. However, it is not clear if and how this will be coordinated at a national level.	Funding is devolved in Sweden and responsibility for implementing the Action Plan lies with the municipalities through their association.
USA	According to the NETP, the use of openly licensed educational resources is one of the most	The USA currently spends USD 8 billion (6 billion GBP) per year purchasing commercial learning

Country	Description	Funding
	effective ways to provide high-quality learning materials at scale.	resources. The strategy suggests significant savings could be made if states made a significant switch to open licensed resources. The strategy consists of recommendations for States to implement and fund.

Source: Appendix 1 country reports

In **Australia**, the government has developed on online portal specifically to build pupils' digital capability. Other countries such as **Austria**, **Czech Republic**, **Denmark**, **Estonia**, **Ireland** and **Japan** have developed online databases of resources linked to the subjects across the curriculum – in some, such as Japan, as a response to the pandemic. While these are sometimes provided centrally by the central government or its agencies, in other countries, such as **Estonia** and the **Netherlands**, these resource portals are co-created by educators and companies or, as in **Finland**, by consortia of publishers and providers.

Case study: public-private partnerships in the Netherlands

The Netherlands has made open-access of educational resources a priority. According to the Digitalisation Strategy 2.0 this should be through public-private partnerships with publishers, distributors, and software providers which centre on the education sector as a user, which should be put first in the partnerships. The Netherlands support SIVON, a cooperation between school boards that are jointly committed to achieving a better match between supply and demand on the educational resources market.

The Agenda for implementing the digitalisation strategy also states that an open and accessible educational resources market is key to ensuring healthy market forces and that it is important to improve coordination between supply and the demand from schools, so that supply will have a lasting impact on education.

Open educational resources are identified as the preferred approach in **Italy** and the **USA**.

Case study: open source as a solution in the USA

According to the NETP, the use of openly licensed educational resources is one of the most effective ways to provide high-quality learning materials at scale. Open licenses should make the use of resources possible without paying any licensing fees or requesting permission. Besides cost savings, openly licensed materials could also be more accurate than traditional textbooks, because they can be updated continually as content changes. Finally, the strategy states that openly licensed materials allow teachers to exercise their own creativity and expertise, so they can tailor learning materials to meet the needs of their students. The Department of Education of the USA suggests efforts to achieve this are already under way in California, Illinois, and Washington State.

Norway has adopted a mix of approaches to support the curriculum.

Case study: a mix of approaches in Norway

As part of its covid response to support online learning, the Directorate for Education and Training published a list of information and resources and all schools received free access to tools for online teaching.

To support the schools, counties and municipalities in implementing digital skills as an integrated part of the curriculum, the Norwegian Centre for ICT in Education developed the digital resource “IKTplan” which provides links and resources covering the competence goals in the curriculum.

The Feide platform hosts a number of third-party digital tools covering a wide range of subjects and ages; some are free but most seem to require schools to pay (at least for full functionality).

For the upper secondary school level, 18 of the 19 county authorities (all except Oslo) have come together to establish a digital learning resource portal, the National Digital Learning Arena (NDLA). Some resources are bought from publishers and commercial content providers. The remainder of the resources are developed by teachers and moderated by universities and university colleges. The content provided is freely available to all students and teachers. The NDLA aims at providing high quality digital learning resources in all upper secondary subjects.

The Norwegian Centre for ICT in Education has established ‘ICT in Practice’, a portal that encourages teachers to share resources and practices.

Accessibility

This section provides details on how the countries covered by this report use, or intend to use, digital technologies to support the education of children with special educational needs and disabilities (SEND). Although many digital strategies make mention of the power of digital learning tools to adapt to individuals' progress and, by implication, to enhance inclusivity, surprisingly few have specific SEND related goals or initiatives:

- In **Austria**, the interface of the digital school portal is designed according to the principles of accessibility and can be used on a range of devices.
- In the **Czech Republic**, experts from special education consultancy centres, which focus on pupils with special educational needs, provide schools with instructions on how to operate and use specific technology for students with special needs and their teachers.
- In **France**, the digital educational resources bank (BRNE) supports the inclusion of students with SEND as well as facilitating their parents' monitoring of their education. Support is also provided for resources designed specifically to meet the needs of students with learning disabilities or autism, in particular through the Ministry's Edu- Up system.
- Accessibility was an important element in **Ireland's** Digital Strategy for Schools 2015-2020 which linked ICT to provisions in the UN Convention on the Rights of Persons with Disabilities.
- In **Japan**, the Ministry for Education provides assistive computers which support input/output for children with visual, auditory, and physical disabilities.
- Through the Statped agency, the **Norwegian Government** supports the development of learning resources for special educational needs which are available free of charge to schools. One of Statped's main tasks is to further develop and implement technology that can benefit users on an individual basis.
- As part of its COVID-19 response, the Special Education Authority (SPSM) in **Sweden** has gathered its digital offerings that can now be accessed through a single portal. Schools can also download a free publication on digital learning and opportunities with digital tools for children and students with disabilities.

Staff training

This section looks at what the countries in this review do to support both their ITE and their CPD to ensure they have the competence to use digital technology proficiently to support teaching and learning activities. This sometimes overlaps with the following section on technical support, in that teachers may require both technological and pedagogical support to harness the potential of digital technology in the classroom. This section, therefore, covers ITE and CPD; those initiatives that provide practical peer-to-peer support for teachers are covered in the next section. The following table sets out central and local approaches in each country.

Table 18: Training

Country	Central government	Funding
Australia	The University of Adelaide's Digital Technologies Massive Open Online Courses (MOOC) provide free professional learning for teachers on the Australian Curriculum: Digital Technologies, and free access to the latest digital technologies equipment through a National Lending Library as a part of the National Innovation and Science Agenda (NISA) package.	Through the National Innovation and Science Agenda (NISA), the commonwealth government invested $50.6 million (26.4 million GBP) over four years (1 July 2016 – 30 June 2020) to support Australian teachers and students in implementing the Australian Curriculum: Digital Technologies. While this largely consisted of grants to schools for innovative projects and offers to children with disadvantaged backgrounds, it also funded other initiatives, such as the training offer from the University of Adelaide.
Austria	From 2017, all new teachers were required to achieve digital skills during their first three years in the job based on a national digital competences model. A training course is offered to in-service teachers through a distance learning MOOC. Differing levels of ICT skills among teachers became more apparent during the COVID-19 school closures. The digital plan aims to prepare all teachers well for blended and distance learning. This will include intensified continuing professional development.	In 2020, the Austrian Government announced funding of 250 million euros (208.7 million GBP) by 2024 to support the implementation of the Digital Master Plan. It is not clear how much of this will be used to fund training.

Country	Central government	Funding
Czech Republic	ITE includes compulsory ICT training.	In-service teacher training is funded by the national budget through approved courses. No funding figures were found.
Denmark	The government defines competency profiles for ITE that providers must meet. A key aspect of the four-year test programme with 40-50 participating schools is looking at the skills needs of teachers and a decision will be made as to whether an entirely new subject or discipline regarding technological understanding should be developed.	Central government funds ITE and subsidise professional development, which is not compulsory. The four-year test programme has been allocated a budget of DKK 68 million (7.6 million GBP) for 2018–2021.
Estonia	Digital learning has been a focus for teachers' professional development in recent years. The professional standards for teachers, which form the basis of initial teacher education and continuing professional development, have recently been updated (2020) with an increased focus on digital pedagogy. Estonia has created digital competence models for teachers based on the European Commission's educator's digital competence framework DigCompEDU.	No specific funding has been identified in the literature.
Finland	A project within the Strategic programme of 2015 included the reform of pre- and in-service teacher education through the introduction of digital materials and new learning environments which will be facilitated through digital-	While this is centrally funded, no figures are available.

Country	Central government	Funding
	pedagogic training. Every Finnish teacher was to be offered access to online learning starting from their own level.	
France	France's digital strategy has teacher's digital competence as a priority. New teachers entering the profession need digital certification, and a new master's degree in digital education has been introduced to develop specialist ICT teachers. Since 2016, lower secondary teachers must complete a three-day digital training course.	We do not have figures for the level of funding.
Ireland	Teachers' professional learning was one of the four themes of the 2015 – 2020 digital strategy. Digital Skills was established as one of the seven core elements incorporated for the first time into the revised Teacher Standards published by the Teaching Council in October 2020. The Department of Education also issued a guiding framework for teacher educators. The effective use of digital technologies in teaching, learning and assessment is an integral part of all department funded CPD programmes.	While funding figures are available for the overall strategy, we have no information on the funding for training.
Italy	A key strategic element of the PNSD has been a training plan which aims to train the entire school staff in the skills needed to manage digital transformation. Over time, policy has moved from developing skills in using	The PNSD included 450 million euros (375 million GBP) for fostering the acquisition of digital competences, teacher training for innovative practices, and other accompanying measures.

Country	Central government	Funding
	technology towards the pedagogical use of ICT in different subjects.	
Japan	In 2021 MEXT placed a particular emphasis on CPD for teachers in order to improve their confidence and skills in using ICT in the classroom.	No information on funding for this is available.
Netherlands	The Digitisation Agenda for Primary and Secondary Education highlights the importance of (1) the education sector and the business community working together to produce digitally literate teachers and (2) the development of programmes to support teachers, school principals and administrators with innovation questions.	No information on funding for this is available.
Norway	Norway has identified the lack of teachers' digital competence as a barrier to the realisation of the ambitions in the digital strategy. A Professional Digital Competence Framework for Teachers was developed by the Norwegian Centre for ICT in Education and launched in May 2017. Its main purpose is to establish a framework for describing teachers' professional digital competence that can be used by national, regional and local authorities, by teacher education institutions, and teacher educators, to inform teacher education programmes and professional development programmes.	In 2017, the Ministry of Education committed NOK 90 million (7.5 million GBP) for the use of digital technology in teacher education (see Case study: future classroom laboratories in Norway). The aim is to ensure that student teachers develop the professional digital competence that they need. The Ministry of Education supports a programme of grants/cover for teachers taking part in professional development (participation in professional development is not mandatory for teachers in Norway).

Country	Central government	Funding
Sweden	The Digital Strategy sets out the ambition for digital competence for leadership and teaching staff. The Action Plan emphasised the need for improvement in teacher and school leadership training programmes and in-service training for school staff. However, those developing training (university providers) were not involved in developing the action plan and it is not clear what levers are available to enhance training programmes.	There is no funding attached to the digital strategy.
USA	Teaching with technology is a priority in the digital strategy of the USA, which includes teacher training, advancing educational technology in teacher preparation, and ongoing CPD.	Funding and implementing the recommendations of the strategy is largely the responsibility of the states and systems vary between them.

Source: Appendix 1 country reports

The majority of digital strategies make reference to the importance of digitally competent teaching staff. The initial education of teachers, in terms of the standards and frameworks that govern courses, are typically set by national governments and it is clear in many countries that the digital content of these programmes has often been strengthened.

The cost of ITE is ongoing and the content of training is frequently updated – as a result, funding figures relating specifically to the use of digital technology are not generally available. However, Norway has made targeted funding available to ITE providers for innovative approaches.

Case study: future classroom laboratories in Norway

Future Classroom Lab (FCL) in initial teacher education provides national support for institutions who are building FCLs for their student teachers. Created by European Schoolnet, a FCL is a fully equipped, reconfigurable teaching and learning environment that is intended to:

- support personalised learning;
- increase student engagement; and
- harness new and emerging technology.

In 2018, three teacher education institutions had set up their own labs, with others planned. While these are independent initiatives by higher education institutions, the Ministry of Education and Research does provide financial support for digital developments in teacher education institutions in the form of a call launched in 2017 for a total of NOK 90 million (7.5 million GBP) for professional development over 3 years, which can be applied for to support such initiatives.

Countries are also interested in improving the digital competence of serving teachers (as well as those entering the profession) and this has given rise to central offers such as Massive Open Online Courses (MOOC), free for teachers to join, in a number of countries. Other countries such as **Austria**, **Denmark**, **Estonia** and **Norway**, have developed digital competency frameworks for teachers to guide both ITE and ongoing professional development. These may be influenced by the framework developed by the EU (see case study below). While such frameworks may influence CPD offers, the extent to which these are centrally funded and developed varies, with few countries – only **France** and the **Czech Republic** - making participation in CPD in digital technologies a requirement for some teachers. For others, participation (and funding support) is likely to be a decision made between individual teachers, their school and, perhaps, the local authority.

Case study: the European Framework for the Digital Competence of Educators

The EU has promoted and detailed digital competence through DigCompEdu, the European Framework for the Digital Competence of Educators (Redecker, 2017) on which some countries' frameworks are based. The DigCompEdu Framework aims to capture and describe educator-specific digital competences by proposing 22 elementary competences organised in 6 areas:

- Area 1 is directed at the broader professional environment, i.e. educators' use of digital technologies in professional interactions with colleagues, learners, parents and other interested parties, for their own individual professional development and for the collective good of the organisation.
- Area 2 looks at the competences needed to use, create and share digital resources for learning effectively and responsibly.
- Area 3 is dedicated to managing and orchestrating the use of digital technologies in teaching and learning.
- Area 4 addresses the use of digital strategies to enhance assessment.
- Area 5 focuses on the potential of digital technologies for learner-centred teaching and learning strategies.
- Areas 6 details the specific pedagogic competences required to facilitate students' digital competence.

The Framework also proposes a progression model to help educators assess and develop their digital competence. This framework aims to inform digital competence models for teachers in member states and its influence can be seen in strategies and/or initiatives for the professional development of teachers outlined in the country reports in Appendix 1.

While most digital strategies concentrate on identifying the skills and knowledge needed by teachers in the classroom, the strategy in **Sweden** also emphasises the digital skills needed by school principals.

Case study: digital competence for school principals in Sweden

According to the strategy, successful integration of information and communication technologies (ICT) in schools requires principals to have the digital skills necessary to lead and support their staff in digital development work. This also means that school leaders need to be able to identify and assess the relevance of new digital solutions and develop their use based on local conditions and the educational needs of their pupils so that the use of digital technology can contribute to improved knowledge outcomes and increased educational goal achievement.

Technical support

This section looks at ways in which the various countries provide technical support to schools, although we were able to find very little information in the Anglophone literature relating to most forms of technical support. This may be because support staff(including those providing ICT support in schools) are, in most countries, employed either directly by the school or local authority, and there are no nationally mandated standards or qualifications. However, the literature did provide some information:

- In **Austria**, schools are supported through decision making aids and comparisons as to which platforms offer which functions and which useful combinations result from them, made available on the Education Ministry’s website. Also available are QuickGuides to support school administrators and teachers in using platforms.
- In **Denmark**, the Agency for IT and Learning offers technical support to schools for its systems, portals and services as well as guides and links.
- To assist **Irish** schools in managing technical support, PDST Technology in Education, which coordinates the Schools Broadband Programme, provides a Technical Support Requirements Document, which comprises a template document that a school can modify to its own needs and then send to prospective providers, seeking quotes to provide technical support to their school.
- In **Japan**, GIGA has invested significant funding into supporting the placement of local governments’ ICT engineers to promote ICT in schools.

A number of countries also provide peer-to-peer support through initiatives which designate teachers as trainers or mentors for other teachers in the school, or through school-to-school support where digitally more advanced schools provide support to others at an earlier point in their journey. Such support is likely to be a mixture of both technical support, helping others to understand the technology on offer and its functionality, and pedagogical support for ways in which the technology can enhance teaching and learning. The different schemes are summarised below:

- In February 2022, the Government of **South Australia** announced that the new digital strategy will be supported with a 33 million dollar (17 million GBP) investment to create a new specialist Digital Guarantee Unit made up of curriculum specialists and ICT experts, who will be responsible for providing holistic support to schools to meaningfully integrate digital technology into what students learn and how they learn it.
- The Mobile Learning project in **Austria**, launched in autumn 2015 in cooperation between the Ministry of Education and the Ministry for Transport, Innovation and Technology (BMVIT), is based on a cross-school peer-learning approach where two or three schools with little use of technology in the classroom are mentored by an experienced school to form a regional cluster. Funded by the Federal Chancellery, participating schools were supported by the school of excellence within the Virtual Pedagogical College. "Mobile Learning" was expanded from February 2017 but it is unclear if this initiative is continuing or has been superseded by more recent developments.
- In line with their public-private partnership approach to the use of digital technology, in **Estonia**, Samsung Baltics started several projects from 2014 onwards, with the common idea to train six members of the school (including school leaders) who will proceed to innovate the rest of the school and community. Every year, 8–12 schools are chosen for the full training programme and annual competition where the first prize is 10,000 euros (8,340 GBP). The programme content and training are provided by Tallinn University experts - professors, lecturers and researchers.
- In **Finland**, the Action Plan for the digital strategy proposed the introduction of tutor-teachers: a teacher supporting other teachers to utilise digital material and in harnessing the educational use of ICT. Existing teachers in the school receive additional training and development to take on the role. Actions may include: organising training on digital pedagogy; conducting competence surveys; providing technical guidance or networking with peers. The initial plan committed to having 2,500 tutor-teachers in schools. 23 million euros (19 million GBP) was provided by the government between 2016 and 2019 to train and support the network of tutor-teachers. In addition, education providers estimated that they contributed 2.5 million euros (2 million GBP) from their own funds to the programme.

- The digital strategy in **Italy** (the PNSD) introduced the role of the ‘digital catalyst’, a teacher appointed by the principal in each school, who is responsible for the PNSD implementation. Together with a team of three or four teachers aiding them, they form the innovation team which focuses on three areas: (i) methodological and technological training of colleagues; (ii) involving and motivating the whole school community in digital innovation; (iii) planning and disseminating, in the school and among colleagues, sustainable methodological and technological solutions.
- The government of **Norway** has, since 2015, piloted a teacher specialist project with different types of teacher specialist (11 subject areas) which aims to recruit and retain the best teachers in the classroom and to strengthen schools as learning communities. The project started out on a small scale with 205 specialists and was at first intended to last for two years but has been expanded following a positive evaluation. The government's aim is to recruit 3000 specialists by the end of the pilot, in 2022. The digital strategy cites specialist teachers as a mechanism for improving the use of digital technology in schools.

Evidence gaps and conclusions

Evidence gaps

Van der Vlies (2020), in an analysis of policy papers on digital education in OECD countries, concentrated on primary sources such as government documents, web pages and other public organisations such as Eurydice. As with this research, availability of information was fragmentary, with some countries providing fairly detailed information (at least in some aspects), with other countries providing only very high-level information. This makes comparisons challenging – with absence of published information not necessarily meaning that there was no activity in a particular area. Encountering similar obstacles, we have supplemented the official sources with information from academic sources where available; while few, if any, of the Anglophone publications focus on the objectives informing this research, some have useful introductory sections on digital policies and outcomes in the relevant country, often drawn from sources not available in English. This is obviously not without limitations, namely that we are unable to verify the accuracy of how policies are represented in the literature, which may be reflective of the views of the author(s) and that, inevitably, translation of strategies or other policy documents will be partial and focused on the object of their research.

A particular gap in the literature relates to any attempt to evaluate the cost-effectiveness of digital strategies or other initiatives to increase the use of digital technology in schools. This may reflect the fact that digital strategies as a whole often do not have funding attached – funding, where it exists, is often attached to specific initiatives arising from the strategy, such as those which provide peer-to-peer support for teachers or schools from more experienced practitioners. In addition, digital strategies often require action from stakeholders at different levels, particularly where many decisions are devolved to local authorities or to schools themselves, meaning implementation can be highly variable making evaluation of impact challenging. Lastly, some aspects of digital strategies relate to strengthening the use of digital technology within ongoing programmes with long-established funding streams such as initial teacher training, teacher CPD and curriculum content so that costs relating to the use of digital technology cannot easily be identified. Consequently, evaluations have, for the most part, been relatively small-scale, are often perception studies, and tend to highlight barriers rather than evaluate impact.

Conclusions

The countries in this report vary widely in their approaches to making decisions about technology in schools; however, curricula and initial teacher training, and, to a lesser extent, teachers' CPD, are often central responsibilities. Requiring particular skills to be developed in pupils, and subsequently assessed, can act as a lever for central governments to increase the use of digital technology in schools, even where much of the decision making in education is devolved. Consequently, a number of centrally funded initiatives such as online training for teachers, creating resource banks and peer support are often linked to curriculum implementation. The limited number of evaluations conducted do suggest that the decentralised nature of schools in most countries in this review make implementation of some aspects of the digital strategies challenging, so such leverage can be an important tool for realising governments' ambitions.

There are, perhaps, surprisingly fewer aims in the digital strategies relating to management information systems, although several countries have, or are planning to introduce, single-sign on portals that enable schools, pupils, parents and carers to share information and access resources. Schools, or municipalities, are generally free to select their own management information systems, although some strategies are considering interoperability issues, with **Estonia** putting an interoperability platform at the heart of its use of digital technology agenda.

Digital infrastructure and broadband seem, for the most part, to be the responsibility of ministries other than those concerned with education and, in the case of those countries in the EU, often linked to the wider EU strategy and supported by EU funding. In particular, there is a concern for ensuring digital equity between urban and rural areas (particularly highlighted in **Ireland**, **France** and the **Czech Republic**) and, in some countries, most notably the **USA**, with affordability for low-income households. These concerns have been highlighted by the move to at-home learning as a result of the pandemic (which also drew attention to a lack of access to devices for some pupils and variable digital skills in teachers). However, moves to improve broadband speeds and access will benefit schools and pupils too.

Digital infrastructure in schools, as well as device provision, seems to be generally a local responsibility and, consequently, difficult to manage effectively through centrally developed digital strategies which rely on local actors to commit to their implementation, which the limited evaluations available suggest can be a challenge. Alongside this, common challenges predominantly related to the implementation of digital strategies in highly devolved systems, which required local authorities and/or schools to use their devolved budgets to meet objectives relating to the use of digital technology when they may feel they have other priorities.

Overall, therefore, we have identified features common to many digital strategies. Most digital strategies have a stated aim of improving pupils' digital skills, which is often linked to their subsequent economic participation and the future prosperity of the country. This, in turn, requires pupils to have access to appropriate infrastructure and devices, and teachers who are sufficiently digitally competent themselves to be able to teach those skills effectively. Consequently, enhancing teachers' digital skills through initiatives such as CPD, competence frameworks, online training and pedagogical and technical support from more skilled colleagues are the most common features of digital strategies in this review. Improved digital infrastructure and changes to the curriculum are the next most frequently included objectives. Countries are increasingly embedding the use of digital technologies in other curriculum subjects instead of, or as well as, having ICT as a subject in its own right.

This review considered available evidence in winter of 2021/2022; not all evidence sources considered had taken into account the impact of COVID-19 on the use of education technology. To inform future policy development, researchers suggest the following options for further research:

- An international review of the impact of the COVID-19 pandemic on schools' use of digital technology including:
    - the ways in which institutions used technology during school closures and how (and to what extent) education technology mitigated learning losses;
    - any barriers to the effective use of technology exposed by the pandemic, such as pupils' access to hardware, poor digital infrastructure and lack of digital skills in pupils, teachers, parents and carers;
    - how lessons learnt regarding the use and effectiveness of education technology have informed the development of post-COVID-19 digital education policies and strategies.
- An international comparison of how schools in different countries develop pupil skills in digital technology in national curricula and if, and how, these skills are assessed.
- How different countries approach ensuring teachers have the necessary capability to use digital technology to effectively support pupils' learning, through initial teacher education and continuing professional development.

Appendix A: Country reports

Australia

Summary and gaps

Over recent years, the commonwealth government in Australia has exercised increasing levels of central control over education through levers such as introducing a national curriculum and a new system of funding contributions to states and territories linked to obligations. While there is not a national digital strategy (although some states have developed one), the curriculum does include requirements both at subject level and in cross-curricular ‘capability’ requirements. In addition, through the Digital Literacy School Grants fund and the National Innovation and Science Agenda (NISA), the central government has funded a number of projects and initiatives intended to improve the digital offer in schools, often targeted at those in low socioeconomic groups.

With states and territories having responsibility for public schools in Australia, two have published digital strategies – New South Wales (NSW) and South Australia (SA), although the latter is still in development. Rural and remote schools are a particular issue in Australia, so the digital strategies look to improve access to learning in these schools.

Funding and autonomy in Australian schools is complex and varied with moves in recent years to increasing autonomy at school level. The central government’s offer tends to focus on schools rather than federal governments, with offers of direct grants for innovative projects and workshops for students to which schools can sign-up. The digital strategies in the two states, on the other hand, have ambitions for infrastructure and platforms for all public schools in their jurisdiction.

Although we have found numerous examples of public investment (at commonwealth and federal level), we have not found evidence of evaluations of impact or cost-effectiveness.

Overview of school system

Education in Australia is primarily the responsibility of the six states and two territories. The age at which schooling becomes compulsory is six years in all states and territories, except Western Australia and Tasmania, where it is five years. In practice, most children start the preparatory year of primary school at between four and a half and five and a half years. All states and territories require young people to participate in schooling until they complete Year 10 and to participate full time in education, training or employment, or a combination of these activities, until the age of 17. Upper secondary education in years 11 and 12 is not compulsory in Australia and examinations taken in that phase vary across the states and territories (Masters, 2018; Australian Government website, accessed 3/2/2022).

Schools are classed as government or non-government schools. State and territory governments have been responsible for delivering school education in their jurisdiction since Australia became a federation. This includes registering and regulating schools (whether government or non-government) and operating government schools. However, the Australian Government has a role in education funding and national policy. While the Commonwealth does not operate any schools or employ any teachers, funding responsibility is shared between the Australian Government and state and territory governments, and national education policy is decided by all governments working together through the National Cabinet.

Government schools are those schools operated by state or territory departments or agencies and include open or comprehensive schools, selective, special, and specialist schools. Government schools are free; however, they may ask parents to pay a contribution for things such as stationery, textbooks, sports, uniforms, school camps and other schooling costs that are not covered under government funding.

Non-government schools are categorised as Catholic schools (including Catholic-affiliated independent schools) or independent (other non-government schools). Schools from the non-government sector may operate as individual schools, in small groups or as a system such as those coordinated by the Catholic Education Commission in each state and territory. They may charge fees.

In 2021 approximately two-thirds of all school students attended government schools; with the remaining one-third of students educated in non-government schools. Regardless of whether a school is government or non-government, it is still required to follow the national curriculum framework (Department of Education, Skills and Employment website, accessed 3/2/2022).

Until relatively recently, each of Australia's six states and two territories set their own curricula which could be quite different from each other. This changed in the first decade of the millennium as the federal government become progressively more involved with the education of the nation's children (Masters, 2018). In 2008, all federal governments agreed a national curriculum was needed to deliver an equitable, quality education for all young Australians and the national curriculum was developed over a number of years. The Australian Curriculum, Assessment and Reporting Authority (ACARA) is an independent statutory authority which was established in 2008 with responsibility for curriculum development, assessment and reporting at the national level. This curriculum was rolled out by subject areas, with the first version made available in 2010 and technologies added to version 6.0 in 2014. The curriculum was completed in 2016 (ACARA website, accessed 3/2/2022).

The curriculum is presented as a developmental sequence of learning from the foundation year to year 10 and describes to teachers, parents, students and others what is to be taught and the quality of learning expected of young people as they progress through school (ACARA website, accessed 3/2/2022). Implementation of the Australian curriculum is the responsibility of Australian states and territories. Jurisdictions, systems and schools are able to implement the Australian curriculum in ways that value teachers' professional knowledge, reflect local contexts and consider individual students' family, cultural and community backgrounds. Schools decide how best to deliver the curriculum and determine pedagogical and other delivery considerations that account for students' needs, interests and the school and community context (ACARA, 2019).

Funding

The funding of schools in Australia is complex and has undergone many changes in recent years. The National School Resourcing Board was established in line with recommendations of the 2011 Review of Funding for Schooling. It provides independent oversight over Commonwealth school funding arrangements. The Australian Education Act 2013 (the Act) is the main legislation for Commonwealth funding to government and non-government schools.

Schools receive funding from both the Australian Government and their state or territory government. States and territories are the majority public funder of the government sector in line with their constitutional responsibility. The Australian Government is the minority public funder. The Australian Government has historically been the majority public funder of non-government schools, reflecting its commitment to supporting parental choice and diversity in the schooling system. State and territory governments are the minority public funders. Australian Government funding to non-government schools takes into account the capacity of school communities to contribute to school's operating costs, for example, the ability of parents to pay school fees.

While 4 out of every 5 school funding dollars comes from public sources, it is not evenly distributed across sectors. On average, around three quarters of funding for Catholic schools and less than one half of funding for independent schools is from public sources. In contrast, almost 95% of funding for schools in the government sector comes from the Australian Government and state and territory governments. The Australian Government share of school funding has been increasing over time with the Australian Government share of total public funding increasing from 73.1% in 2009-10 for non-government schools to 76.2% in 2018-19 and 10.8% in 2009-10 to 15.6% in 2018-19 for government schools.

From 2018, the Australian Government introduced a funding model based on the Schooling Resource Standard (SRS), which is a measure of the amount of public funding needed by each school to meet the educational needs of its students. Unlike the previous arrangements where the Australian Government contribution of the SRS varied between states and territories, the Australian Government is moving towards consistently funding:

- 20% of the total SRS for government systems, reflecting its role as the minority public funder of this sector, and
- 80% of the total SRS for non-government schools and systems, reflecting its role as the majority public funder of this sector.

Schools currently funded below their target Commonwealth share of the SRS will transition to the target by 2023 and schools that are currently funded above their target Commonwealth share will transition to it by 2029 at the latest.

Under the Australian Education Act 2013, states and territories must meet minimum funding contribution requirements for both government and non-government sectors as a condition of receiving Commonwealth funding. State and territory governments have discretion to fund above these requirements. Minimum state and territory funding requirements from 2018 to 2023 are outlined in bilateral reform agreements which commenced on 1 January 2019 and were signed by the Australian Government and each state and territory. The National School Resourcing Board must undertake an annual review of each state and territory's compliance with minimum funding contributions.

The bilateral agreements also outline state-specific reform activities to improve student outcomes and sit alongside the National School Reform Agreement that sets out long term national goals for education and came into effect from 1 January 2019. It is a joint commitment between the Australian Government and the states and territories to lift student outcomes across Australian schools. The aim of the National Agreement is that Australian schooling provides a high quality and equitable education for all students. The National Agreement sets out eight national policy initiatives in areas where national collaboration will have the greatest impact (NB none of these explicitly reference the use of digital technology in schools).

(All information from Department of Education, Skills and Employment website, accessed 3/2/2022)

Brief description of digital strategy

There is no overarching digital strategy for Australia as responsibility for public schools lies predominantly with the states and territories. However, the national government does provide financial support for initiatives related to digital aspects of the curriculum.

Two states – New South Wales and South Australia – have produced digital strategies.

Priorities and timescales

While there is not an overarching digital strategy for schools in Australia, two states – New South Wales and South Australia – have produced their own.

New South Wales

The Schools Digital Strategy 2019 -2026 (SDS) is a seven-year roadmap intended to empower schools to determine their own digital future and support them with the digital skills and tools they need to succeed. Components of the SDS include:

Rural, regional, and remote schools should be brought up to the digital equivalent of their metropolitan counterparts through its Rural Access Gap (RAG) programme by delivering the following:

- More than 12,000 teachers will have access to a portable device.
    - More than 220,000 students will benefit from a higher availability of devices to reach a minimum device-to-student ratio of 1:4.
    - More than 13,000 learning spaces will have access to a Main Learning Display (interactive display).
    - 1,004 rural and remote schools will achieve network connectivity of 5 Mbps per student.
- Fast, reliable and secure internet connectivity is being delivered as part of an infrastructure upgrade of rural and remote schools which will help close the digital divide with their metro counterparts.
- To support teachers and students to access new learning modes developed for future-focused learning by using current and emerging digital technology. These include:
    - Learning on a large scale – Virtual group assembly. Those in regional or remote schools can remain connected to the wider school community, and students can get real-time feedback from their teachers no matter where they are.
    - Learning together – Collaboration at school. Students can learn on their own terms working together to investigate, explore and create in evolving learning spaces.
    - Self-directed learning – Inside the school. Students are encouraged to self-direct as they learn in connected learning environments. They have choice in how they access and share content, and teachers will provide guidance and upskill students in using new digital tools.

    - Self-directed learning – Outside the school. Students will direct their learning in a connected home. Digital technology provides access to resources selected by teachers, guided instruction and digital collaboration tools from anywhere.
    - Learning from visiting experts – Incursions. Visiting educators can lead practical learning experiences for audiences large and small.
    - Learning by visiting experts – Excursions. Students can enhance physical excursions by using digital technology to record their observations and communicate with peers and teachers. Virtual reality tools can also enable students to explore the world providing rich, authentic learning when limitations on excursions present challenges.
    - Direct learning – Inside the school. Content management systems can transform small group activities into open and collaborative spaces. Teachers can support regional schools using tools such as video conferencing, and engage in more targeted face-to-face teaching, reaching more students with streamlined and consistent content.
- Direct learning – Inside and outside the school. Teachers can facilitate activities and content accessed in real time by all students and provide collaborative learning and immediate feedback.
- Providing better infrastructure and skills. While rural and remote schools are prioritised, the intention is that students across the state will benefit from better connected and equipped learning spaces purpose-built to support engaged and personalised learning. This involves improved connectivity, easier access to quality resources, and training and support for teachers.

These solutions, which were co-designed with schools, are embedded in a delivery roadmap that is structured over three horizons spanning seven years:

1. The Rural Access Gap proof of concept (POC) covered 29 schools as part of Release 1 of the programme. The POC was extended to 110 schools by the end of June 2021. The programme will be rolled out to the remaining schools over the subsequent two years.
2. Service delivery, digital infrastructure, processes and platforms are extended throughout the public school network. Principals can browse a digital service catalogue as new needs emerge; teachers blend digital elements seamlessly into their lesson delivery; parents and carers gain full visibility of their child's learning journey; and continual innovation becomes the norm as new and emerging technologies are fully leveraged.
3. Digital delivery becomes fully integrated across the department of education and sector-leading expertise is developed. Students enjoy equitable access to digital

resources and smart devices, and the department provides strategic advice based on data-driven insights.

South Australia Digital Strategy

In 2021, the Government of South Australia announced that they are developing a new digital strategy that will outline the department's digital approach over the coming years. The digital strategy will:

- set a clear vision for using digital technology across our education system
- outline how we use digital technology to maximise student learning
- outline how we can prepare children to learn, live and work in a digitally driven world

The digital strategy will focus on 6 key themes:

1. ensure the right digital foundations are in place
2. build strategic, leadership and people capability
3. support digital adoption, integration and innovation for teaching and learning
4. provide appropriate ICT support in schools and preschools
5. modernise workplaces for business operations
6. improve access to data and platforms and improve data literacy (Government of South Australia website accessed 5/2/2022)

Is there funding attached to strategies/initiatives and how is this devolved?

National Innovation and Science Agenda

The Australian Government, through its National Innovation and Science Agenda (NISA), invested $50.6 million (26.4 million GBP) over four years (1 July 2016 – 30 June 2020) to support Australian teachers and students in implementing the Australian Curriculum: Digital Technologies.

This funding provided support for:

- Grants to school principals and Information and Communication Technology (ICT) leaders for projects to implement the Australian Curriculum: Digital Technologies through a whole of school approach;

- Online professional development courses for teachers through expansion of the University of Adelaide's Digital Technologies Massive Open Online Courses (MOOCs);
- Online computing challenges for all Year 5 and Year 7 students (aligned with Australian Curriculum: Digital Technologies) that provide structured teaching and learning modules to support the curriculum;
- ICT summer schools to engage Year 9 and 10 students, with a focus on those from disadvantaged backgrounds, to increase their participation in digital technologies and STEM studies in school, post-secondary school and the workforce;
- Cracking the Code - a series of fun and engaging computing and coding challenges and activities for school students, to be held in National Literacy and Numeracy Week, published on the National Literacy and Numeracy week website;
- Teacher support for digital technologies to provide in-class support and/or telepresence support and follow-up to schools in the early stages of implementing the Australian Curriculum: Digital Technologies; and
- Developing effective partnerships between Science, Technology, Engineering and Mathematics (STEM) professionals and schools to build teachers' and students' understanding of STEM applied in the real world.

The Grants to Schools element of the offer saw the government commit 4 million euros (just over 2million GBP) over 2 years (1 July 2016 – 30 June 2018) to provide schools with grants for projects, that will encourage, facilitate and inspire the effective implementation of the Australian Curriculum: Digital Technologies on a whole of school basis. Through these grants, the aim of the programme was:

- to stimulate best practice models of implementation of, and student and teacher engagement in, the Australian Curriculum: Digital Technologies;
- encourage sharing of ideas and experiences in relation to the Australian Curriculum: Digital Technologies, within and among schools;
- facilitate the development, implementation and sharing of demonstration projects that can be used by other schools to implement the Australian Curriculum: Digital Technologies; and
- facilitate effective ways that leaders can inspire their teachers and students to extend and apply their learning across other learning areas through the Australian Curriculum: Digital Technologies.

Schools applied to the government for grants.

New South Wales Digital Strategy

Funding for this seems to be part of a three-year Digital Restart Fund (DRF) which commits 1.6 billion euros (approx. 836 million GBP) over that period. In June 2021, the NSW government announced that an extra 500 million euros (261 million GBP) would be added to the fund over 3 years ((NSW government website, accessed 5/2/2022). In addition to the of the use of digital technology in schools, DRF funding includes a range of initiatives to digitalise the public sector. Closing the digital gap between regional and metropolitan schools has, so far, received the largest allocation of DFR funding. The state government, in November 2020, announced that, over two years, 365.8 million euros (191 million GBP) is to be invested in teacher training, infrastructure and digital platforms with automation capabilities. A total of 85 million euros (44 million GBP) of this funding will be immediately released to 97 schools through the DRF (NSW government, 2020). Budget allocations are announced annually, so there is no figure available for the seven-year lifespan of the strategy.

South Australia Digital Strategy

In February 2022, the Government of South Australia announced that the new strategy will be supported with a 33 million euros (17 million GBP) investment to create a new specialist Digital Guarantee Unit made up of curriculum specialists and ICT experts, who will be responsible for providing holistic support to schools to meaningfully integrate digital technology into what students learn and how they learn it. The unit will also be responsible for delivering on the strategy's commitment to equity in students' access to technologies. 23 million euros (12 million GBP) of new spending will be invested to improve access to devices for students, as well as provide home-based internet solutions for families where cost is a barrier. In addition, the unit will help to build digital capacity within the teaching workforce through tailored training and support, and work with schools to ensure all teachers have a quality device to support their work (South Australia Government media release, 2022).

Does the strategy provide a rationale for the level at which decision making to support the digital strategy and associated funding is delegated? (NB: this should also include relevant information on school/local autonomy in the country and the levers available to support strategy implementation)

The Australian school system is complex with six state and two territory public education systems (comprising around two-thirds of all students), the Catholic sector (comprising just under a fifth), and the independent sector, ranging from predominantly faith-based small to large elite schools (comprising around 15% of all students) (ACARA, 2020). Public schools are state responsibilities, with private and Catholic schools receiving federal funding.

Independent Public Schools are public schools that have greater autonomy over spending and decision making. They remain part of their government school system and continue to receive support from state governments. They must not charge tuition fees to parents or have selective enrolments processes. There has been a focus in Australia on creating more autonomy within public school systems (Keddie et al., 2020) with the conservative federal government in 2015 committing 70 million euros (36 million GBP) to 'build on current developments across the states to help schools become more autonomous and independent if they so choose' (Australian Government, 2016).

However, the extent to which schools have moved towards greater autonomy has varied between states and territories, with Victoria undergoing a programme of increasing school autonomy since the early 1990s and New South Wales maintaining a more centralised approach. The implementation of the IPS policy in Western Australia (WA) reflects a recent radical restructuring of that state's public education system with the conversion of 575 schools to IPS status (Keddie et al., 2020).

While not provided as rationales, the approach to the use of digital technology in schools from the commonwealth government, with its focus on curriculum implementation, reflects the limitations of the role of central government in effecting change in schools. The digital strategy in New South Wales, on the other hand, reflects the role of the state government in a state in which relatively few public schools have moved towards independent status.

What evidence is there of approaches/initiatives instead of, or in addition to, a digital strategy?

The Australian Curriculum

The curriculum, along with initiatives designed to support its effective implementation, is the main way in which the government is able to influence the use of digital technology in schools. Prior to the Australian curriculum, teaching with and about digital technologies was overlaid in other curriculum areas and would have varied between states and territories, as well as between schools (Masters, 2018).

The technologies subject area within the curriculum provides students with the opportunity to learn about and work with traditional, contemporary and emerging technologies within two distinct but related subjects: Design and Technologies, and Digital Technologies. In Digital Technologies students purposefully use computational thinking and information systems to define, design, implement and evaluate digital solutions.

In addition to subject specific content, the curriculum also describes 'general capabilities' which are represented to varying degrees across the subject areas. The ICT capability involves students developing knowledge, skills and behaviours that enable them to responsibly use ICT tools associated with: information access and management, information creation and presentation, problem solving, decision making, communication, and creative expression (ACARA, 2019).

In 2020, ministers agreed the terms of reference for a review of the curriculum to be published in 2022. The aim of the review is to improve the Australian Curriculum F-10 by refining, realigning and decluttering the content of the curriculum within its existing structure and underpinned by the education goals of the Alice Springs (Mparntwe) Education Declaration (2019) that was endorsed by the Council of Australian Governments Education Council. One of those goals was to produce ‘successful lifelong learners who are productive and informed users of technology as a vehicle for information gathering and sharing, and are able to adapt to emerging technologies into the future’ (ACARA, 2019). States and territories will implement the revised Australian Curriculum according to their own timeline after its publication at some point in 2022 (ACARA website, accessed 3/2/2022).

As a part of the Australian Government’s National Innovation and Science Agenda, ACARA was funded to support the implementation of the Australian Curriculum: Digital Technologies in some of Australia’s most disadvantaged schools. The Digital Technologies in focus (DTiF) project was designed to encourage whole-school and inter-school collaboration, supported by curriculum officers. One hundred and sixty schools with a low index of community socio-educational advantage (ICSEA) rating participated in the project. From July 2017, leaders and teachers from these schools have been taking part in workshops to help them implement Digital Technologies. Nine Digital Technologies curriculum officers supported clusters of schools, providing expertise to primary and secondary school teachers. In 2018–20, the Digital Technologies curriculum officers conducted professional learning workshops with teachers and school leaders. These workshops are customised to the specific needs of participating schools, with webinars and online mentoring complementing face-to-face events. Additional workshops were offered to other schools (ACARA website, accessed 3/2/2022).

The digIT summer schools will give Year 9 and 10 students from lower socioeconomic backgrounds the chance to attend a digital technology-based summer school, followed by five months of mentoring and a follow-up residential school. The digIT programme is funded by the Commonwealth of Australia through the Department of Education and run by AMT. It is part of the National Innovation and Science Agenda’s “Inspiring all Australians in digital literacy and STEM” measure, which aims to increase the participation of young Australians in science, technology, engineering and mathematics (STEM) and to improve their digital literacy (Australian Maths Trust website, accessed 3/2/2022).

Which bodies take decisions about spending in the delivery chain from government to individual schools and colleges?

For public schools, the majority of funding comes from the state or territory. Whether decisions take place at school level or state level varies according to state or territory and school status. For independent schools (including independent public schools) this will be at school level, although some schools (predominantly catholic independent schools) may be part of a cluster in which decisions may be at cluster rather than school level (Masters, 2018).

In 2017, school autonomy levels over resource management (allocation and use of resources for teaching staff and principals) were higher than the OECD average: 75% of decisions in Australia were taken at the school level, compared to the OECD average of 29% (OECD, 2019). However, the OECD also notes that “school funding has lacked transparency and coherence, and outcomes of numerous studies have shown the difficulty in determining how individual schools are funded.”

Overview of bodies taking decisions about technology choices

Australia works in a shared national education system in agreement with states. The education system is steered nationally through agreements with states and territories, focused on education priorities and funding. Schools and states share most decision making in lower secondary education, with schools making most decisions regarding the organisation of instruction (OECD, 2019).

Specific decision areas (centralised or devolved) and links to strategies and funding

Broadband connectivity

New South Wales: the digital strategy includes application of the Internet@Edge solution, improved school network connectivity (Wi-Fi), and is part of a $328 million (171 million GBP) partnership between the NSW government and Telstra to upgrade connectivity to all mainland NSW schools. The initiative will deliver one of the major targets of the Rural Access Gap programme – network connectivity of 5 Mbps per student in 1,000-plus Rural Access Gap schools.

In South Australia, the government spent £130 million to upgrade internet speed in public schools although it is not clear over what time span this money was spent (South Australia Government media release, 2022).

Digital infrastructure (including Wi-Fi, switching and cabling, servers and cloud storage and internal networking in school/college buildings) The NSW digital strategy, while focusing initially on remote and rural school, pledges to enhance infrastructure across all schools during its seven-year life cycle.

The South Australian digital strategy also pledges to ensure that the right digital foundations are in place but this has yet to be translated into concrete proposals.

Data (interoperability, security)

No information found.

Back-office systems (the software that supports the technology)

No information found.

Accessibility (for example, audio visual)

No information found.

Hardware (for example, laptops, desktops, tablets, peripherals)

While we have been unable to find more recent figures, OECD reported that the 2012 PISA results revealed that in Australia, every 15-year-old had individual access to a computer at school and 93.7% of pupils of all ages of students used computers for their school work. This was the highest in OECD countries at the time (OECD, 2015).

The NSW strategy states as an aim that there will be equitable access to digital resources and smart devices but there is no more detail available yet. For rural, regional and remote schools, a priority of the strategy is that 12,000 teachers in those schools will have access to a portable device and more than 220,000 students will benefit from a higher availability of devices to reach a minimum device-to-student ratio of 1:4.

Software (for example, Management information systems, HR, finance, safeguarding, monitoring and filtering)

The South Australian Department for Education announced in September 2018 a new Education Management System (EMS), a student-centred online service for public schools and pre-schools. Key features of the EMS will include:

- a single student record that captures all the relevant information about a child's progress in the public education system
- easier recording of enrolments, family information and movement between schools

- a teacher toolkit to make it simpler to record attendance, behavior management, prepare reports, plan and communicate
- high quality timetabling and scheduling tools
- learning management system to make it easier to track and report on student learning, homework and assignments
- financial management tools to support budgeting, invoicing and procurement
- parent/caregiver portal with 24-hour access to timetables, homework, notifications, events, attendance and achievement
- school administration tools to support site and facilities management
- business analytics to provide teachers, principals, education directors and the department with reports and data to support and guide decision making

The digital schools management solution will be rolled out across the state's 900-plus public schools by Civica in partnership with Frog Education and EdSmart with a ten-year roll out at a cost of the system at $82.3 million (43 million GBP) (Civica website, accessed 5/2/2022; IT news website, accessed 5/2/2022).

Curriculum and business administration choices

Through the National Innovation and Science Agenda (NISA), the commonwealth government invested $50.6 million (26.4 million GBP) over four years (1 July 2016 – 30 June 2020) to support Australian teachers and students in implementing the Australian Curriculum: Digital Technologies. This largely consisted of grants to schools for innovative projects and offers to children with disadvantaged backgrounds.

The Digital Technologies Hub is an online portal that supports implementation of the digital technology aspects of the Australian Curriculum. The Digital Technologies Hub was developed by Education Services Australia for the Australian Government Department of Education, Skills and Employment. It includes learning resources and activities for students and teachers to build their digital capability. It also supports school leaders to develop a whole school plan. In addition, families can find resources to help them support children to develop skills and plan a career. As well as free resources, it also links to a range of commercially available resources (software and hardware) (Digital Technologies Hub website, accessed 3/2/2022).

The Australian Government is commissioning the development of a range of curriculum resources to assist with delivery of AI and emerging technologies content in the Australian curriculum. The resources will help to engage students and support the professional learning of teachers (Department of Industry, Innovation and Science website, accessed 3/2/2022).

Staff training University of Adelaide's Digital Technologies Massive Open Online Courses provide free professional learning for teachers on the Australian Curriculum: Digital Technologies, and free access to the latest digital technologies equipment through a National Lending Library as a part of the National Innovation and Science Agenda (NISA) package (University of Adelaide website accessed, 3/2/2022).

Both digital strategies reference teacher skills but with little detail.

Technical support

No information found.

Cyber security

Cyber security seems to be largely the responsibility of states/territories to manage. For example, in 2020-21 plans, the NSW government Customer Service Cluster (how the public interact with government services) committed to investment of $240 million (125 million GBP) over three years through the Digital Restart Fund across the public sector. It is not clear if this involves schools.

How (and by how much) infrastructure is funded, and how this investment is supported and delivered

The government is providing affordable high-speed broadband across Australia through the $29.5 billion (15.4 billion GBP) public equity investment in the National Broadband Network. The roll-out was completed by 2020 (Department of Industry, Innovation and Science website, accessed 3/2/2022).

Evidence of the cost effectiveness of different models

We could find no evaluations of cost effectiveness in the literature.

Austria

Summary and gaps

Schools have a great deal of autonomy in Austria when it comes to decision making, although the federal government does have levers at its disposal such as curriculum frameworks, pupil testing and teacher training that enable it to improve the knowledge and use of digitisation in schools. However, the focus of the digital strategies has largely been about supporting schools and teachers to make informed choices about digitisation through the use of training, portals, guides, technical support and seals of approval. There is also support for broadband connectivity.

As part of Austria's digital education strategy "School 4.0 – Let's get digital", Austria started introducing an innovation package (2017). This package provided broadband to schools, aiming for full coverage by 2021, and established a foundation to support innovative projects in schools. In 2018, a new Master Plan for Digitalisation in Education was announced, with details published in 2020, replacing the previous strategy, with the aim of full implementation by 2023 and associated funding of 250 million euros (212 million GBP).

While the 250 million euros (212 million GBP).over three years that accompanies the latest digital strategy is not broken down into specific spending areas, it seems likely that the majority of the investment is in the centrally available offer, rather than devolved directly to schools with the hope and expectation that schools will see the benefits of the free resources (as well as the offer of support from other, more digitally advanced schools) to improve their own practice and realise the ambitions outlined in the strategy.

Overview of school system

Compulsory schooling starts for all children on September 1st following the child's sixth birthday and comprises nine years. Ninety% of children aged 6-15 attend state-funded schools, with the remainder either educated privately or at home.

School Types in Austria

- Primary school (Volksschule) (6 to 9 years)
- Special needs school (Sonderschule)
- New secondary school (Lower secondary school) (Neue Mittelschule) (10 to 13 years)
- Pre-vocational year (Polytechnische Schule) (14 to 15 years)

- Secondary academic school (Allgemeinbildende hYeshere Schule) (10 to 17 years)
- Vocational school (Berufsschule) (14 to 18 years)
- Secondary technical and vocational school (Berufsbildende mittlere Schule) (10 to 17 years)
- Secondary technical and vocational high school or college (Berufsbildende hYeshere Schule) (14 to 18 years) (Austrian Government website https://www.help.gv.at/Portal.Node/hlpd/public/content/141/Seite.1410000.html accessed 6/1/22)

The governance and administration of the education system is divided in Austria into three levels:

1. federal/central level: Federal Ministry of Education, Science and Research
2. provincial level (9 provinces and 9 boards of education)
3. local level (municipalities)

The Federal Ministry is responsible for legislation and execution (in some cases together with the newly established 'board of education') of all matters pertaining to:

- The entire system of higher-level secondary general education (age 10-18, grades 5-12) and the entire system of intermediate and higher-level technical and vocational education (age 15-19; grades 9-13)
- Curricula
- Structural set-up of the educational authorities
- Private schools
- Teacher education and training
- Grants and funding
- Federal/provincial level

The 2017 Education Reform Act altered education governance, moving from regional boards of education to a single authority, the board of education - a joint authority of the Federation and the provinces – to ensure maximum transparency with standardised regulations for all provinces. The allocation of resources for schools is carried out by the board of education according to legally defined criteria, predominantly based on pupil numbers. Maintenance of the buildings is supported by the provinces with financial grants (for example province school construction funds).

The Education Reform Act 2017 also brought changes at regional/local level. Below the provincial level, 31 educational regions were established. The number of educational regions in the federal provinces is between 1 and 7 regions, depending on the number of pupils and topographical conditions. The educational regions are set up as branch offices of the Boards of Education.

School administration at local level is fulfilled by municipalities as they are responsible for the maintenance (construction, running, closing) of general compulsory schools. These tasks are assigned to the municipalities by provincial legislation and implemented by the municipalities under the supervision of the provinces, which will grant financial support (for example province school construction funds).

School administration at institutional level is fulfilled by the school heads and the school partners. School heads are responsible for pedagogical matters, organisational development, staff recruiting and management, quality management, management of resources and school partners (school forum, school community committee). On the basis of the 2017 Education Reform Act, schools have not only been given more autonomy in the organisation of teaching, for example, but also in the recruitment of staff. Between two and a maximum of eight school locations can join forces in school clusters since the school year 2018/2019. This aims to support innovative pedagogy and the effective use of resources. Clusters can be formed both for compulsory schools and for federal schools, or as a combination of these.

The school clusters are run by cluster management teams, at the individual school locations there are department heads. Cluster managers have the same tasks as school heads (Eurydice, 2021a).

Funding

(All figures are for 2017)

In Austria public schools are either financed:

- completely by the federal state (teacher salaries, maintenance of school buildings) for academic secondary schools (also referred to as federal schools), higher vocational schools, teacher training colleges;
- by the federal state (teacher salaries) and the communities (school maintenance) for primary, lower-secondary, special or pre-vocational schools (also referred to as compulsory schools);
- by the federal state (teacher salaries) and a federal province (school maintenance), for example part-time vocational schools.

According to Article 14 of the Federal Constitution (Bundes-Verfassungsgesetz), the federal government is the provider of secondary schools and colleges (lower and upper secondary level). In the compulsory school sector, the federal government makes substantial transfer payments to the provinces, which are regulated in the Financial Equalisation Act. This states that the federal government will reimburse the provinces for the personnel expenses of teachers under their service prerogative. This includes the costs of provincial contract teachers at public general compulsory schools, which are 100% financed by the federal government, as well as the costs of teachers at part-time vocational schools, which are financed at 50%. In addition, the federal government finances most of the personnel costs in private academic secondary schools, private schools of intermediate VET and private colleges of higher VET. This mainly concerns those private schools that are provided by church organisations. In total, the gross transfers of the federal government in the school sector amounted to EUR 4,201.3 million in 2017. Almost all of these transfers (EUR 4,199.8 million) went to the provinces.

The provinces are responsible for providing teachers at compulsory schools. The majority of the educational expenditure of the provinces (excluding Vienna) is therefore accounted for by personnel costs for schools. In relation to the gross transfers of the federal government, the transfers of the provinces amounting to EUR 185.37 million are small. The recipients of these transfers are mainly municipalities (EUR 92.6 million), private non-profit organisations (EUR 25.6 million) and other public law bodies (EUR 23 million).

Vienna’s expenditure is determined separately each year by the national statistical authority (Statistics Austria). This is a result of Vienna’s special status as both a province and a municipality. Due to this special position, Vienna has increased expenditure in general and vocational compulsory education. The gross transfers of EUR 14.6 million made by Vienna are mainly received by municipalities (EUR 9.2 million) and private non-profit organisations (EUR 4.9 million).

The expenditure of the municipalities is mainly due to material expenses at primary schools, compulsory secondary schools, special needs schools and prevocational schools. Municipalities and regional associations of municipalities are the largest providers of general compulsory schools. As such, they are responsible for the construction and maintenance of school buildings and other properties as well as for the provision of non-pedagogical staff (for example school caretakers, cleaning and supervisory staff). The gross transfers of the municipalities and associations of municipalities in the school sector amounted to EUR 263.4 million in 2017. Of this amount, EUR 120.4 million went to municipalities and EUR 86.2 million to companies.

The funding of schools is determined by the class sizes regulated by law, demographics and school selection behaviour in academic secondary schools, schools of intermediate VET and colleges of higher VET. The number of required classes and teachers is derived from these framework conditions. A small part of the funding is used for the further development of the school system. For example, funds are made available to finance additional teaching staff. This aims to reduce class sizes, promote language support classes and expand day care in schools, for instance (Eurydice, 2021b).

Brief description of digital strategy

A digital strategy of four pillars was launched in 2017 for implementation from 2017/2018. This strategy (4.0) was replaced by the 8-point Masterplan Digitalisation in Education (2020) which builds on the earlier strategy and other initiatives.

In a Eurydice entry (November 2021), the Austrian Government representation states that: “Under the old 'School 4.0 strategy' various actions have already been implemented:

- a new subject 'basic digital education' was introduced at lower secondary level in 2018/19
- a pilot project started in primary school providing an initial programming experience
- a modular teacher training on digital skills and digital didactics ('digi.folio') was set up combined with peer learning in 400 schools on the use of tablets while the school development network 'eEducation' was expanded
- teacher training is reinforced through the setting up of 'Education Innovation Centers' as virtual learning areas in teacher training colleges
- digital text books in secondary school became e-books

The new 8-point plan has the following areas of intervention:

- As of 2020/2021, a single gateway, the portal ‘Digitale Schule’, has become the prime platform for applications and communication between students, teachers and parents.
- Uneven ICT skills among teachers became more apparent during the COVID-19 school closures. The plan aims to prepare all teachers well for blended and distance learning. This will include intensified continuing professional development.
- Eduthek provided access to learning and teaching material during the crisis. Now its content is to be more closely harmonised with curricula.
- A new good practice label should assist teachers to choose effective learning Apps.
- In 2021/2022, a purchasing programme starting with school levels 5 and 6 will upgrade IT infrastructure so that all students have access to devices. Purchasing

is based on local demand and is linked to a compulsory digital and pedagogical plan for each school." (Eurydice, 2021)

Priorities and timescales

The digital strategy (4.0) 'It's getting digital' was launched in 2017 by the Austrian Federal Ministry of Education (BMB) and focused on four pillars: basic digital education in primary and lower secondary schools; digital skills for educators; infrastructure and IT equipment; and digital learning tools and digital education media.

Pillar 1: Digital basic education from primary level onwards. The emphasis in primary school was on the third and fourth school years and focused on media education as well as on using technology and developing problem solving skills in a playful way. In addition to media education, digital basic education is gradually included in the curricula which is defined nationally. Early adopter schools began to implement the model during the school year 2017/18. Experience is passed on to all other schools in the form of best practice examples and transfer of know-how (see eEducation Austria below). In addition, from the fifth to the eighth grade, the compulsory subject "Digital Basic Education" covering 2 to 4 lessons per week will be introduced. The school decides autonomously about the specific design of the content of the lessons which can be integrated in existing school subjects or delivered through specific lessons. At secondary level, students should be able to master basic skills in informatics as well as deal with standard programs by the end of year 8, with a second focus on the critical handling of social networks, information and media. The expected competencies are defined by "Digikomp 8" and are measured through testing.

Pillar 2: Digital Competent Educators. According to the Ministry for Education, the prerequisites for achieving the above goals are well-educated teachers who use digital media effectively in their classes. They must have digital competencies and media competency in order to be able to pass them on to the pupils. These competencies were defined in the "digikomp" model. From autumn 2017 onwards, all new teachers were required to achieve standardised digital skills during their first three years in the job, presenting these in a compulsory portfolio that demonstrates their digital competencies, including using technology in learning scenarios. In order to be able to expand their digital competences in professional life, a training course is also offered to in-service teachers through the University Colleges of Teacher Education or through the Virtual University College of Teacher Education (set up by the ministry to promote digital learning and to support the nationwide networking of schools). Education Innovation Studios (EIS) have been established at University Colleges of Teacher Education in all federal states. They pursue the goal of increasing the competences of teachers regarding child-friendly programming environments, robotics and creative digital design. In addition, the first Austrian Future Learning Lab was set up in cooperation with the Federal Ministry of Families and Youth (BMFJ) at the Pädagogische Hochschule Vienna. There, teachers can experiment with digital tools and are trained to use them.

Pillar 3: In 2017, around 50% of secondary schools maintained by the Federal Ministry (federal schools) had access to wifi in all rooms and 96% of classrooms had internet access. In primary and secondary schools maintained by regional authorities (compulsory schools), 31% of all classes had Wi-Fi, while 78% of the classrooms had Internet access. The BMB launched a broadband initiative for compulsory schools in cooperation with the Austrian Ministry for Transport, Innovation and Technology (BMVIT). The "Connect" funding programme of BMVIT pursues the goal of achieving a sustainable improvement in the connection of compulsory schools to the glass fibre network. We were unable to find any information on the level of funding or how this is disbursed. Together with local school authorities, the BMB developed recommendations for a basic IT infrastructure in schools. The BMB also negotiated framework agreements with internet providers to offer special conditions for educational institutions, which means that the running costs are kept as low as possible. In cooperation with the Austrian Internet Offensive, the BMVIT and the Austrian Association of Communities developed technical support to schools and local school authorities. The strategy also set out a medium-term goal of the Ministry of Education to equip all 86,000 pupils in the fifth grade with tablets and all 84,000 pupils in the ninth grade with laptops. Initially, the "Bring Your Own Device" concept was being promoted which, by 2017, was already implemented in 35% of the Federal Schools.

Pillar 4: In order to be able to communicate digital content, teachers need easy and free access to teaching and learning materials according to the government. Through OER (Open Educational Resources), content is made available and the active use of digital media is encouraged. Eduthek is a portal for digital teaching and learning materials. It pools a wide range of content and media and makes them accessible via a central entry point. The content includes teaching and learning materials, recommended educational apps and games. Model-driven deployment scenarios show teachers how to effectively integrate digital media into their lessons.

One of the priorities identified by the Austrian Government in 2020 was Digitalising the Austrian School, including digital devices for every student; installing the Austrian education cloud; developing digital school service portals; and expanding digital competencies of teachers (Austrian Government Programme 2020 – 2024).

More details for achieving this ambition are set out in the Digital Schools Master Plan, 2020. The vision for the digital school in Austria is for the development of digital skills resulting in a comprehensive understanding, learning with digital media, learning about digital media and creating a basic understanding of how the digital world works. It argues that "meta-knowledge about digitisation is absolutely necessary because it is constantly evolving and permeating and changing our society". In addition, the development of digital, media-related and IT basic skills offers the opportunity to promote analytical, logical and abstract thinking across disciplines. Learning can be made more self-determined, transparent and individual. If used correctly, the possibilities of digitisation can help promote curiosity, the joy of learning and sustainable learning success in schoolchildren. Pedagogues can assign the effectiveness and success of their work more directly and expand their range of methods. Teamwork, joint preparation of teaching content and project work are made much easier through stronger networking. Parents can better recognise and support the learning success of their own children." (Austrian Government website https://digitaleschule.gv.at/ accessed 28/12/21).

The plan is divided into three major fields of action:

Field of activity 1: "Software" - pedagogy, teaching and learning content. In the course of a fundamental revision of existing curricula, new teaching and learning content from the field of digitisation is to be systematically incorporated into the curricula. The aim is to map a comprehensive basic understanding of how to deal with new content in the curriculum and to take the use of digital technology into account in all subjects, methodologically and didactically, in modern teaching.

Field of activity 2: "Hardware" - infrastructure, modern IT management, modern school administration. The infrastructural equipment and the availability of mobile devices should be brought to a unified and comparable standard. The prerequisite is to be created across the board so that digital instruments and tools can be used in schools. School administration is to be simplified through modern applications.

Field of activity 3: "Teachers" - training and education. This includes new ways of communicating content and developing understanding in students. Opportunities to acquire the necessary skills should be systematic in the initial training or the continuing education and training of pedagogues.

The plan states that the prerequisite for achieving the positive effects described is that technological offers are always designed and implemented in the service of pedagogy. It sets out a timetable for achievement:

- 2020-Uniform platforms and the digital school portal simplify communication between teachers, learners and legal guardians. Teachers train themselves specifically for the use of digital teaching and learning methods.
- 2021- In the 5th and 6th grades, schoolchildren learn with mobile devices. Teachers and learners work with competence-oriented digital materials.
- 2022- Quality-assured learning apps support schoolchildren in learning.
- 2023- The IT infrastructure at federal schools comprehensively meets the framework conditions for digitally supported teaching.

- 2024- Digital learning is well established in all schools.

More detailed aspects of the plan are listed below under specific headings.

Is there funding attached to strategies/initiatives and how is this devolved?

We could find no evidence of the degree of funding attached to the 2017 strategy as a whole.

The Foundation for Innovation in Education 2017, which focuses in particular on the topics of digital education and accelerating EduTech, was endowed with 50 million euros (41.8 GBP) in 2017 (Federal Chancellery and Federal Ministry of Science, Research and Economy, 2016).

In 2020, the Austrian Government announced funding of 250 million euros (212 million GBP) by 2024 to support the implementation of the Digital Master Plan. No Anglophone information could be found for the details of this funding but it seems most likely, given the autonomy of school decision making and the details of the central offer, that the funding is largely intended to develop central offers of resources, training and support.

Does the strategy provide a rationale for the level at which decision making to support the digital strategy and associated funding is delegated? (NB: this should also include relevant information on school/local autonomy in the country and the levers available to support strategy implementation)

The strategies themselves do not provide details of the assignment of any associated funding nor a rationale for the delegation of decision making. However, this should be viewed in the context of school autonomy levels over resource management being higher in Austria than on average across the OECD: 50% of decisions in Austria were taken at the school level, compared to the OECD average of 29% (OECD, 2019). The OECD also identified the division of responsibilities between the federal and the provincial governments as a significant challenge in the current governance and funding arrangements. “Within the funding system, resource allocations were based almost entirely on student numbers and thus, lack flexibility, transparency and trust, among provinces and the municipalities” (ibid.).

The Federal Parliament in Austria is responsible for basic legislation, and the Länder (regional authorities) are responsible for issuing and implementing laws with regard to the organisational structure of federal education authorities in the Länder and the external organisation of public sector schools within compulsory education. Basic laws enacted by the federal parliament will normally prescribe a deadline by which the Länder must issue the relevant implementing laws (within six months to one year) (Lehner, 2017).

What evidence is there of approaches/initiatives instead of, or in addition to, a digital strategy?

The gradual implementation of digital basic education in primary and lower secondary education started with a pilot at innovative schools of the eEducation network (Lehner, 2017). The eEducation Austria initiative of the Federal Ministry of Education (BMB) was designed to help schools and teachers to use digital media as a didactic tool in all subjects and to increase the ICT competencies of all participants in Austrian schools. In addition to the development of teaching, the focus is on a comprehensive view of the entire school community and not just on individual teachers. It provides a structure for schools to network and the transfer of knowledge and experience from the so-called expert schools that support less digitally proficient schools through joint projects and training measures. In 2017, around 1,800 schools were involved in the eEducation initiative, 700 of them as experts with an annual target of 2000 participating schools by 2018 (Lehner, 2017).

The Mobile Learning project, launched in the autumn of 2015 in cooperation between the Ministry of Education and the Ministry for Transport, Innovation and Technology (BMVIT), is based on a cross-school peer-learning approach and shows how much pupils benefit from the use of digital media. The project was based on the know-how and experience of the eEducation network. Two or three schools with little use of technology in the classroom were mentored by an experienced school to form a regional cluster. Funded by the Federal Chancellery, participating schools were supported by the school of excellence within the Virtual Pedagogical College through a one-year project the which also offers training for teachers and Safer Internet workshops in schools for teachers and students. The evaluation of the first round concluded that individual learning is promoted and pupils with different learning profiles worked well on common tasks and in teams. The teachers at the participating schools felt lesson quality increased and saw improved networking and cooperation with the colleagues within their own school and with other schools. "Mobile Learning" was expanded from February 2017 from 94 locations in 31 clusters to 171 schools in 55 clusters (Lehner, 2017). It is unclear if this initiative is continuing or has been superseded by more recent developments.

Which bodies take decisions about spending in the delivery chain from government to individual schools and colleges?

At school level the Federation (meaning in particular the Federal Ministry of Education, Science and Research - BMF) has primary responsibility for school organisation, the organisation of school instruction and private schools. These matters are all governed by federal legislation. This covers all types of schooling up to and including year 13, including post-compulsory secondary in both the academic and vocational pathways.

With the 2017 Education Reform Act there was a reorganisation of school administration. This was taken over by boards of education, a joint authority of the federation and provinces from January 2019.

Below the provincial level, 31 educational regions were established. The number of educational regions in the federal provinces is usually between 2 and 7 regions, depending on the number of pupils and topographical conditions. The educational regions are set up as branch offices of the boards of education.

Schools already had considerable autonomy in budgetary management and adapting curricula to local needs. With the Education Reform Act, they were also granted greater autonomy with regard to the organisation of teaching and schools and in the selection and development of personnel. To use resources effectively, schools are able to join together to form clusters.

In the compulsory school sector, most of the expenditure is financed by the federal government and transferred to the provinces, which, as the responsible body, spend these funds on schools. In the elementary sector (crèches, childcare facilities for infants and toddlers, kindergartens, after-school day care facilities and mixed-age care facilities), on the other hand, the provinces provide the majority of funding, some of which is passed on to the municipalities in the form of transfers (Eurydice – website accessed 29/12/21).

The Federal Ministry of Education, Science and Research is responsible for universities, universities of applied sciences, and university colleges of teacher education. The ministry also has responsibility for adult education and training along with, to a lesser extent, other ministries (Eurydice).

Overview of bodies taking decisions about technology choices

In specific matters enumerated in the Constitution, the federation sets the framework, while detailed legislation is implemented by the parliaments of the provinces. The federation has overwhelming responsibility for the education system, including virtually all areas of school organisation and the organisation of school instruction (Eurydice).

In Austria, motivating schools to develop their own digital strategy is the overall goal of the national digital strategy but they are not compelled to do so. Rather, they are encouraged to take responsibility and recognise the need to actively tackle the use of digital technology. “Each school should therefore develop a plan to implement digital education in the best possible way, and ideally including the following items: teaching digital competences, the pedagogical use of technology in various subjects, optimising infrastructure, collaboration and communication and teacher competences, and teacher training (CPD)” (European Commission/EACEA/Eurydice, 2019).

Post-compulsory secondary is subject to the same arrangements as lower secondary, with different approaches for universities and adult education.

Specific decision areas (centralised or devolved) and links to strategies and funding

Broadband connectivity

A prerequisite to fully exploiting digitisation in education and accelerating the use of IT in schools is school-wide provision of basic IT infrastructure. The framework conditions for digitally supported teaching at federal schools will be significantly improved by 2023. All federal schools should have a high-performance broadband connection based on fibre optics as well as high-performance and sufficient WLAN coverage in individual classrooms (Austrian Government, Digital Master Plan).

The BMB launched a broadband offensive for compulsory schools in cooperation with the Austrian Ministry for Transport, Innovation and Technology (BMVIT) in 2017. The "Connect" funding programme of BMVIT pursues the goal of achieving a sustainable improvement in the connection of compulsory schools to the glass fibre network. Together with local school authorities, the BMB has developed recommendations for a basic IT infrastructure in schools. They provide the basis for a development plan for the improvement of technical infrastructure in schools. The BMB has also negotiated framework agreements with the providers. They offer special conditions for educational institutions, which means that the running costs are kept as low as possible. However, the decision to take advantage of this is at school level (Lehner, 2017).

Three goals planned by 2023 are:

1. Fibre optic connections. Creation and expansion of in-house basic infrastructure - secondary and tertiary connection (cabling in the school building).
2. WLAN / LAN equipment in classrooms. The first expansion branch with fibre optic connections began in 2020 with 39 federal schools at 32 school locations. The sustainability of the planned investments is to be increased through standardization, so that future expansion measures can be carried out with the least possible need for new equipment. The recommendation for a basic IT infrastructure worked out jointly with the school owners serves as the basis for expanding the technical infrastructure.
3. For compulsory schools, the Broadband Austria Connect funding initiative with a funding rate of 90 % is available for expanding broadband (Austrian Government, Digital Master Plan). (NB it is not clear whether this funding comes from the 250m euro funding for the Digital Master Plan or represents an additional funding stream. It is also not clear who applies for the funding at the local level).

We have been unable to find detailed information on funding. While it is clear that the government have ambitions for improving infrastructure, this is largely focused on access to high-quality broadband and networking within schools. The 2017 Digital Strategy had the ambition of ensuring this was realised by 2021 but the extent to which this has been achieved is unclear, although improving this remains an aim of the Master Plan for 2023. In 2017, federal schools (those run by the government and funded directly) seemed to have greater wifi access than compulsory schools (those run by the municipality). The Connect programme for compulsory schools offers a grant of 90% of the cost of connectivity. However, it is unclear how much, if any, of the 250 million euros (212 million GBP) is earmarked for this nor how this will be transferred to schools or municipalities.

Digital infrastructure (including Wi-Fi, switching and cabling, servers and cloud storage and internal networking in school/college buildings)

The infrastructural framework for digitally supported learning is to be optimised. Federal schools will be connected to fibre optics and adequate wifi will be available in all classrooms (Austrian Government, Digital Master Plan). (NB, we have no information on cloud storage or servers).

Data (interoperability, security)

The digital school portal (see section on software for more details) that has been set up by the Austrian Government does not collect any information about the user, but offers assistance with daily school administrative processes. Personal data that the portal displays is protected, and comes from existing applications. The portal is operated by the Federal Computing Center, which has the highest standards of data protection and security (Austrian Government, Digital Master Plan).

Back-office systems (the software that supports the technology)

No information found.

Accessibility (for example, audio visual)

The interface of the digital school portal is designed according to the principles of accessibility (AA) and can be used on the desktop and on mobile devices (Austrian Government, Digital Master Plan).

Hardware (for example, laptops, desktops, tablets, peripherals)

In order to ensure equal opportunities and up-to-date teaching, all secondary school students should be given access to and equipped with a digital device under the same conditions. In order to ensure access to their own learning device for all secondary school students, the issue of digital devices is planned for the 5th and 6th grade in the 2021/22 school year, and in the 5th grade from the 2022/23 school year.

The purpose of the initiative is to create the pedagogical and technical prerequisites for IT-supported teaching and to enable schoolchildren to have access to digital education under the same conditions. This includes teaching digital skills and learning how to use mobile devices correctly, as well as how to use these devices optimally for better learning opportunities.

The access of every interested school to the device initiative “digital learning” should be as low-threshold and pragmatic as possible. A school can register for the initiative by means of a letter of intent. By signing this declaration, each participating school confirms its intention to develop into a digital school and, step by step, to develop four quality areas: school development and control, infrastructure and technical support, pedagogy as well as further and advanced training. The school decides on the operating system. Legal guardians of pupils are expected to contribute 25% of the cost.

According to the ministry’s website, the programme being set up covers three tasks:

- Conduct a call and a selection procedure for schools with a use of digital technology concept
- Procure mobile terminals and commission the necessary external services in cooperation with the Austrian Federal Procurement Agency (BBG)
- Plan and carry out a funding programme to acquire the equipment

It is unclear what is meant by a funding programme. This may refer to the 25% to be sought from parents and carers (and it is not clear what happens in the event that they are unable or unwilling to contribute) or if this suggests that schools are covering the remaining costs or if this is being provided centrally.

As part of the device initiative for schoolchildren, a certain number of devices will also be available for educators in the participating digital classes. This is to ensure that there is a sufficient number of devices in the school that teachers can use to teach in the classes (Austrian Government, Digital Master Plan).

Software (for example, Management information systems, HR, finance, safeguarding, monitoring and filtering)

The most important educational and administrative applications are to be bundled and made accessible via single sign-on through the national digital portal. This also supports improved communication between school and legal guardians.

The digital school portal (PoDS for short) was designed in 2018 by the Federal Ministry of Education, Science and Research as part of the work on the plan for digitisation in education. Right from the start, the aim was to bundle existing applications in order to provide teachers, learners and their legal guardians with consolidated and clear information in an easy-to-use manner and to provide support in everyday school life in different ways. A survey by the Federal Parents' Association in April 2020 (around 12,000 parents took part) showed that the large number of existing tools and applications in schools leads to confusion and misunderstanding. A clear request to politicians was the thinning of these tools and applications and the focus on a portal.

To provide technical support for the digitised learning process of schoolchildren and to be accompanied by educators, the Digital School portal is a uniform platform with single sign-on functionality for all essential applications for education and administration. In a first step, the electronic class register WebUntis, the learning platforms LMS.at and Moodle-Eduvidual, Sokrates Bund and the content portals Eduthek and Edutube were connected to the portal. A search function for learning content offers quick access to numerous exercise materials and learning videos. The electronic class register WebUntis is also integrated directly into the digital school portal, so that pupils and teachers can see their personal timetables in the portal.

The portal has been made available free of charge to all teachers and students at federal schools since September 2020 and access to legal guardians from December 2020 (Austrian Government, Digital Master Plan).It is not clear what the arrangements are for compulsory schools.

Curriculum and business administration choices

Curriculum is broadly set at federal level, with schools able to make decisions about how to adapt and implement requirements within the framework, including the digital curriculum.

The Master Plan recommends that schools should standardise their processes, reduce the number of learning management and communication systems used in the school and thus create clear structures for digitally supported teaching and learning.

It also promises that the range of innovative, high-quality and quality-assured educational media is to be expanded so that teachers and learners are offered the best possible service.

The digital platform Eduthek provides in-depth exercise materials for all types of schools and subjects. The Eduthek bundles content offers using a uniform catalogue system and makes them available to teachers and students with an overarching metadata research and full-text search. It offers clearly prepared learning and exercise material for schoolchildren of all school levels to practice at home and to deepen learning material. In the ongoing expansion of the Eduthek, all digital teaching and learning resources will be aligned with the curriculum. This means that the digitally prepared curricula and the fields of competence to be acquired can be efficiently linked with the digital teaching and learning materials and the content offers for daily teaching can be researched even better.

The Eduthek is linked to the digital school portal.

During school closures due to COVID-19, up to 85 % of all Austrian schools used the Eduthek content. Such high demand was possibly due to the availability of a Massive Online Open Course (MOOC), a free and open online course, on digital learning that was developed by the Austrian Ministry of Education. The MOOC, followed by 15% of Austrian teachers, comprises information on good practices when using Eduthek's content for the teaching of all subjects. After the first lockdown, the user rate of Eduthek went down to 50%.

A seal of approval for materials has been introduced by the government for apps for mobile learning as well as for use in blended and distance learning. The seal of approval is intended to provide parents, teachers and schoolchildren with orientation and assistance in the selection of innovative products that are already on the market. Based on international good practice, learning apps are tested according to various aspects. The focus is on the assessment according to pedagogical criteria. In addition, features such as learning management, cost transparency, presentation of the business model, user friendliness, data protection or technical stability are used for assessment.

A test phase started in autumn 2020 in which the certification process and assessment criteria was evaluated and adjusted using international examples. The first certified offers from the pilot project were available from August 2021 (Austrian Government, Digital Master Plan).

Staff training

The 'Digital Competence Model' provides a reference framework for teachers' digital professionalisation starting from entry into ITE until the end of the fifth year in the profession. The Digital Competence model provides eight areas of competence and indicates at which stage the competences should be acquired. Teachers are expected to progressively evolve from acquiring the basic general digital competences before starting ITE, to developing specific digital competencies during ITE, including the pedagogical use of technologies and expand and update them through continuing professional training. This includes self-assessment tools to enable teachers to chart their progress

(European Commission/EACEA/Eurydice, 2019).

For existing teachers, the Master Plan states that all teachers should be prepared for digitally supported teaching as part of a qualification offensive. The Distance Learning MOOC is offered as a nationwide advanced training event by the government. The Distance Learning MOOC can be completed at any time at the teachers' own pace and regardless of location. There is no charge for participation. Each of the four units contains two central learning videos, additional texts and links as well as reflection questions for practical transfer in order to achieve the learning objectives.

Over 11,000 teachers took part in the first guided round from August 10, 2020. There was a second round in autumn 2020. By completing the MOOC, educators acquire basic knowledge for teaching in digital classes with mobile devices. In preparation for the roll-out of digital devices in lower secondary level, participation is recommended, but not mandated, by the government.

Technical support

The Austrian Government noted that, during COVID-19 school closures, students and guardians perceived learning platforms and communication tools used by teachers as disadvantageous.

To support the implementation of the recommendations for standardising the platforms, documents and assistance are provided on the BMBWF's distance learning service portal. Schools are supported through decision making aids and comparisons as to which platforms offer which functions and which useful combinations result from them. The QuickGuides for prototypical didactic scenarios support school administrators and teachers in using platforms in a didactically meaningful way.

Cyber security

No information found.

How (and by how much) infrastructure is funded, and how this investment is supported and delivered

The Broadband Strategy 2020 aimed to provide nationwide ultrafast Internet access by 2020, in particular in areas where rollout for private companies is not economically viable to bridge the gap between town and country. Measures in the plan include: expansion of the geographical coverage of high-performance broadband networks; connection of existing stand-alone solutions to efficient data highways; and funding of the laying of ducting during construction work for non-discriminatory use for broadband networks. The strategy also requires net neutrality through regulation. The Austrian Government notes that "the more complex the interconnections, the more important it becomes to ensure compatibility and interoperability. Open standards encourage productivity, migratability for consumers, data protection and the economic value chain." The public sector (including schools) is encouraged to use open standards (Digital Roadmap Austria website, accessed 23/2/22). The Broadband Office ("Breitbandbüro") attends to all strategic and operative affairs around broadband (Ministry of Agriculture, Regions and Tourism website, accessed 23/02/22). This strategy is in the process of being replaced by Broadband 2030 which should supply the entire country with fixed-line and mobile gigabyte connections by the year 2030.

The Austrian Government committed to: funding expansion of broadband where this is not viable for the private sector; specifically funding excavation costs to provide a connection for schools or small and medium-sized companies; and developing a strategy to introduce the fifth generation of mobile telecommunications (5G strategy). The public sector committed a total of one billion euros (830 million GBP) of funding (Ministry of Agriculture, Regions and Tourism website, accessed 23/02/22).

Broadband 2030 is being supported by 1.4 billion euros (1.2 billion GBP), 890 million (743 million GBP) of which comes from the EU Recovery and Resilience Facility.

Evidence of the cost effectiveness of different models

The only evaluations that are referenced in the literature is that of the Mobile Learning project noted in the 'What evidence is there of approaches/initiatives instead of, or in addition to, a digital strategy?' section , but this was in relation to teacher perceptions of benefits and costs of the initiative are not available.

Czech Republic

Summary and gaps

The Czech Republic's Digital Education Strategy to 2020, which was in place between 2015 and 2020, formulated 3priority objectives: opening up education to new teaching methods and techniques through the use of digital technologies; improving student competences in working with information and digital technologies; and developing computational thinking among students. Initial evidence suggests the Digital Education Strategy to 2020 has had a positive impact on students' digital skills. We have been unable to find details of the budget associated with the implementation of the strategy.

It is unclear whether the Czech Republic Government intends to introduce a new digital education strategy. However, digital education is a key pillar of the Strategy for the Education Policy of the Czech Republic up to 2030+, which was launched in October 2020 (Ministry of Education, Youth and Sports of Czech Republic, 2020). This strategy aims to support the digital literacy of learners in primary and secondary education, and to strengthen the digital competencies of teachers. This involves embedding digital skills across the curriculum, promoting the sharing of good practice, and providing mentoring for pre-service and in-service teachers (OECD, 2021; Ministry of Education, Youth and Sports, 2020).

Overview of school system

Czech children are required to begin school at age 6 and attend for a minimum of 9 years of basic school (ages 6 to 15). Most of the population (almost 90%) acquire basic education in a basic school which is divided into primary level (years 1 to 5) and lower secondary level (years 6 to 9).

Upper secondary education is provided in upper secondary schools which may be general or vocational. This type of education is post-compulsory. It consists of 2to 4-year programmes, with pupils usually starting these at the age of 15. Multi-year secondary general schools provide both lower and upper secondary education. A small proportion of pupils attend conservatoires rather than upper secondary schools.

Public basic schools are usually established by municipalities or a group of municipalities, however schools can be also established and run by private entities or religious organisations. It is possible to establish a joint institution of a nursery school, basic school or/and upper secondary school. Multi-year general secondary schools or 8-year conservatoires are established mostly by regions.

Private and, to a lesser extent, denominational schools are established at all educational levels. As far as educational programmes, material, and staffing are concerned, private, denominational, and public schools are governed by the same rules, but different conditions are applicable in organisational and financial matters.

Funding

Public schools and school facilities obtain funds from the state budget and from the budgets of territorial administrative units – regions and municipalities. They can also acquire some funds through their economic activities and participation in international programmes.

The method of financing basic schools and upper secondary schools, conservatories and after-school clubs is governed by an amendment to the Education Act of 2020, which introduced a new system for distributing public funds to schools. Funding is allocated to schools directly from the state budget based on a per capita amount per pedagogical worker / one member of education staff. This funding model is designed to guarantee financing of the actual extent of teaching, ie according to the number of hours taught. The budget for schools is laid down directly by the Ministry of Education, Youth and Sports. When allocating the funds, the ministry considers the size and structure of schools in regions, the financial cost of support measures, and the different salary levels of teachers in individual schools (Eurydice: National Education Systems: Czech Republic).

Private and denominational schools continue to be subject to the formula of funding through per capita amounts per pupil/student. Private schools and school facilities are granted subsidies to finance non-investment expenditures related to education and training and current operating non-investment costs from the state budget, through regional authorities on the basis of a contract for the respective school year. These schools usually collect tuition. Denominational schools and school facilities receive subsidies directly from the Ministry of Education based on the same formulas as private schools (Eurydice: National Education Systems: Czech Republic).

Brief description of digital strategy

The Digital Education Strategy to 2020 was put in place to embed digital technology across the education system. The strategy has 3 key objectives: 1) introduce new approaches to learning through harnessing digital technology; 2) improve students' digital competence; 3) develop students' knowledge of information technology.

The strategy was a joint initiative of the Ministry of Education, Youth and Sports and the Ministry of Labour and Social Affairs (MPSV).

It is not clear whether or when a new digital education strategy will be introduced. However, digital learning is included as a strand of Strategic Line 1 (Transforming the content, methods and assessment of education) of the Ministry of Education, Youth and Sports' Strategy for Education Policy of the Czech Republic Up To 2030+. Three core themes are highlighted:

- ensure the promotion of digital literacy for all pupils
- support the digital competences of all teachers
- reduce inequalities and prevent the digital divide (Ministry of Education, Youth and Sports, 2020)

Priorities and timescales

The Czech Republic's Digital Education Strategy to 2020 aimed to promote new approaches to teaching and learning through the use of digital technologies, to improve students' digital competencies, and to develop students' knowledge of information technologies (OECD, 2021). The strategy formulated 3 priority objectives on which the interventions focused from the outset:

- opening up education to new teaching methods and techniques through the use of digital technologies
- improving students' competencies in working with information and digital technologies
- developing computational thinking amongst students (Schoolnet 2018)

Measures included: ensuring equal access to digital infrastructure; ensuring conditions for the development of digital competencies and computational thinking amongst students and teachers; supporting the construction and renovation of educational infrastructure; stimulating and disseminating innovation; helping schools to develop in the integration of digital technologies in teaching and in school life; and improving public understanding of the importance of digital technologies in education (European Schoolnet, 2018; OECD, 2021).

The key themes highlighted in the digital learning strands of the Strategy for Education Policy of the Czech Republic Up To 2030+ are provided in the following box.

Strategy for Education Policy of the Czech Republic Up To 2030: Digital learning

1. Ensure the promotion of digital literacy for all pupils

The transformation of the content of education towards digital literacy and computational thinking, or the use of digital technologies and resources in general, must not be limited to the teaching of information science or related areas, but will become an integral part of education as a whole. Methodical support will be provided to teaching staff for the application of digital technologies in all disciplines across educational areas as a natural part of primary, lower and upper secondary education.

2. Support the digital competences of all teachers

The support of teachers is a condition for the transformation of the content of education and the quality of education in general. As the role of the teacher is irreplaceable in the development of digital education, we will place an emphasis on strengthening the digital competences of teachers, both during their teacher training and subsequently in their further education. It is also necessary to support mentoring and the sharing of good practice when integrating digital technologies into the teaching practice. Support will be given to activities that strengthen teachers' abilities to work with a variety of digital learning resources, to plan and implement the use of digital technologies at different stages of the learning process, to work responsibly with digital content and to build and develop pupils' digital competences.

Technology should be a tool for developing new methods and forms of education and assessment. We will strive to increase the effectiveness of teaching through technology and to truly integrate digital technologies into communication with pupils. Technology will be used to adapt teaching to the pupils' individual needs and to make didactic practices more effective. This transformation will be carried out through methodical support for teachers and the creation of appropriate conditions.

Greater learning autonomy

Teachers and pupils will be assisted by digital tools for the individual assessment of learning outcomes, as well as for self-assessment. We will support platforms that enable pupils to gain greater learning autonomy, as well as the individualised development of their potential. The information and data generated by the new tools will be used to evaluate school curriculums (ie the achievement of learning outcomes) and as a source of information on the training needs of teachers (ie a basis for further training to support the achievement of better learning outcomes).

3. Reducing inequalities and preventing the digital divide

Pupils who do not have sufficient digital competences, access to digital technologies or internet access are at risk of digital exclusion. It is incumbent on the education system to close the digital divide among pupils, regardless of their socioeconomic, health or other disadvantages, by promoting non-discriminatory access to quality education and creating conditions conducive to increasing their digital competences at school, not only in the classroom (for example school clubs, accessible technology for pupils). If digital technologies are available and used appropriately in education in all schools, they can make a significant contribution to reducing educational inequalities.

Source: (Ministry of Education, Youth and Sports, 2020)

Is there funding attached to strategies/initiatives and how is this devolved?

To date, we have been unable to find details of any budgets associated with the implementation of either of the strategies.

Does the strategy provide a rationale for the level at which decision making to support the digital strategy and associated funding is delegated? (NB: this should also include relevant information on school/local autonomy in the country and the levers available to support strategy implementation)

The responsibilities for compulsory schooling and upper secondary schooling are shared amongst the national Ministry of Education, Youth and Sport, regional authorities, municipalities and individual schools. The Ministry of Education, Youth and Sports is responsible for the state, conception and development of the education system as well as for allocation of financial resources from the state budget. The ministry also sets out the general content of pre-primary to secondary education. Regions are responsible for education in their territory (from pre-primary to tertiary professional level) and for the allocation of financial resources to schools. Regions are responsible for upper secondary schools, conservatoires and tertiary professional schools, whereby municipalities establish basic schools (European Schoolnet, 2018).

The use of ICT is a part of the strategic objectives and planning of schools. Steps to be taken in this area are, as a rule, part of an ICT plan of schools. When organising teaching, the majority of schools take the use of ICT into account. The embedding of ICT into curriculums is the responsibility of each school director, but the subject of ICT is included in the curriculum documents for elementary and secondary education. Schools can have official ICT plans if they feel that it is useful for their own work (European Schoolnet, 2018).

At most schools, there is an ICT school co-ordinator, whose duties vary from school to school. According to the ČŠI Thematic Report (CZ), this position is filled at almost 90% of schools with more than 150 pupils, but at less than 50 % of schools with less than 150 pupils. The most frequently mentioned reason for this situation is a lack of financial resources (European Schoolnet, 2018).

What evidence is there of approaches/initiatives instead of, or in addition to, a digital strategy?

Through the Supporting Capacity Building for Basic Literacies in Pre-primary and Basic Education - Supporting Teaching Practice project (2016-21), with EU financial support, the Czech Republic is seeking to build teachers' capacity to develop students' basic literacies, including digital literacy and computational thinking (OECD).

Which bodies take decisions about spending in the delivery chain from government to individual schools and colleges?

School leaders appear to play a central role in purchasing decisions. European Schoolnet (2018) reported that head teachers of basic schools and upper-secondary schools consider ICT equipment as the area where schools should invest the most. It was also noted that support for purchasing digital equipment for schools had been provided by European funds, some of which schools could use not only for purchasing digital devices (such as tablets or laptops), but also for teachers´ training indigital education and for covering costs of IT support staff.

Overview of bodies taking decisions about technology choices

Support for school leaders in making decisions regarding technology includes the 'Profile School 21' portal which is a self-evaluation tool for schools that enables them to determine how successful they have been in incorporating digital technology into school life. 'Profile School 21' focuses on five areas, which include ICT infrastructure and management and planning, ICT in the school educational programme, professional development, and integration of ICT into school life (European Schoolnet, 2018).

Specific decision areas (centralised or devolved) and links to strategies and funding

Broadband connectivity

No information found.

Digital infrastructure (including Wi-Fi, switching and cabling, servers and cloud storage and internal networking in school/college buildings)

The Ministry of Education, Youth and Sports' Strategy for Education Policy of the Czech Republic Up To 2030+ states that in cooperation with school founders (and in consultation with the Union of Towns and Municipalities and Union of Local Government Units in the search for positive examples of practice), the government will allocate sufficient funds to schools and school facilities for the acquisition and ongoing renewal of equipment, and arrangements to ensure the sufficient digital infrastructure at schools. The implementation period is 2021-2023, with funds provided from the state budget – within the framework of the activities of the Ministry and the Comenius Operational Programme (Ministry of Education, Youth and Sports, 2020).

Data (interoperability, security)

Within the 'Resortní informační systém' (Departmental Information System), the Ministry of Education, Youth and Sports is preparing an interface for communication with school information systems which are chosen by schools from products offered by commercial companies, in order to simplify the collection of statistical reports, data and other information within the education sector (European Schoolnet, 2018).

Back-office systems (the software that supports the technology)

School information systems are used by almost all Czech primary, secondary and tertiary professional schools (in the case of small primary schools, with fewer than 150 pupils, the usage rate is slightly lower – systems are not used by about 10% of them). The systems are used for pedagogical and administrative purposes (including schedules and pupil records) as well as to communicate with pupils and their parents (including electronic pupils' record books and information about school events) (European Schoolnet, 2018).

Accessibility (for example, audio visual)

Specialists from special education consultancy centres, which focus on pupils with special educational needs, provide schools with instructions on how to operate and use specific technology for students with special educational needs and their teachers. In addition, ICT school co-ordinators play an important role in directing, guiding, advising and sharing the latest information and developments (European Agency, nd).

The Helpnet.cz web portal (www.helpnet.cz) provides a wide range of information and networking; sharing examples of good practice and innovative software in education and in support of people with special needs (European Agency, nd).

The I-SEN platform (www.iSEN.cz) is for exchanging experience and good practice in iPad and iPod Touch application in education, with special focus on access to education and the inclusion of pupils with special needs (European Agency, nd).

Hardware (for example, laptops, desktops, tablets, peripherals)

See entry for digital infrastructure.

Software (for example, Management information systems, HR, finance, safeguarding, monitoring and filtering)

No information found.

Curriculum and business administration choices

In 2012, the Czech Republic established a free online portal for educators (the National Methodological Portal), supervised by the National Pedagogical Institute (NPI), which aims to support schools/teachers in implementing curricular reform by providing a virtual space for sharing educational materials, texts, ideas, expert discussion and online teacher training courses. (European Agency, 2021; OECD, 2020; European Schoolnet, 2018). By 2020, the portal listed nearly 8,000 methodological contributions, over 10,000 digital teaching materials, a suite of digital tools (Web 2.0), and online courses and webinars; it had 31,000 registered users in 2019.

Through the Supporting Capacity Building for Basic Literacies in Pre-primary and Basic Education - Supporting Teaching Practice project (2016-21), with EU financial support, the Czech Republic is aiming to increase teachers' capacity to develop students' digital skill, including computational thinking and digital literacy. In 2019, professional development modules fostering the use of open digital resources and teachers' digital skills were added. For the latter, a digital tool based on the European Framework of Digital Competences for Educators (2017) maps teachers' digital competences through self-evaluation. Such efforts provided a valuable resource base during the shift to online learning caused by the COVID-19 pandemic (OECD, 2020).

The 'Profile School 21' web portal (Profil Škola 21, http://skola21.rvp.cz/) is an important evaluation tool developed by the National Institute for Education as part of the National Methodological Portal. The 'Profile School 21' portal is geared towards allowing individual schools to self-assess their integration of ICT into school practice, planning for its further development. It is based on different indicators monitoring the level of implementation of ICT into the educational process (management and planning, ICT in the educational process, professional development, integration of ICT into school life, ICT infrastructure). The data is collected and is used by each school and by the Ministry of Education, Youth and Sports as a source of knowledge for future changes and development at school and/or national level (European Agency, nd).

Staff training

Initial teacher training (at university level) includes compulsory ICT training. Specialists from the SECs and/or support centres for inclusive education instruct teachers on how to operate and use specific technology for students with special educational needs.

In-service teacher training (including training for teachers, ICT teachers and ICT school co-ordinators) is systematically funded by the national budget through Ministry of Education-approved courses (European Agency, nd).

A wide range of lifelong learning courses, e-learning courses and web portals targeted at ICT literacy are available, as well as specific courses/portals for people with special educational needs. Teachers' needs in this area are monitored regularly in order to meet these needs (European Agency, nd).

NGOs, organisations operated by the Ministry of Education, Youth and Sports, universities, educational companies and specialised professional organisations (such as the Union of School IT Professionals – Jednota školský ch informatiků (www.jsi.cz)) contribute to increasing the professional development of ICT specialists/teachers, in addition to administering targeted monitoring and providing recommendations to policymakers (European Agency, nd).

Technical support

Administration of ICT equipment in schools is most often provided by a third-party service. The European Schoolnet (2018) indicates that the support offered does not always fully correspond to needs of schools. In addition, due to a lack of financial resources for this area, the administration of all ICT resources in a school is (on average) limited to a maximum of 10 hours per month.

Cyber security

The key national body overseeing cybersecurity in the Czech Republic is the National Cyber and Information Security Agency (NCISA, in Czech: NUKIB), which was established in 2017 to increase the focus on new and emerging threats. One of the NCISA's main areas of activity is support of education in the field of cyber security.

How (and by how much) infrastructure is funded, and how this investment is supported and delivered

The National Plan for the Development of Very High Capacity Networks (VHCN), approved in March 2021, defines the strategic approach of the Czech Republic to the construction of VHCN, with a particular focus on areas with no access to VHCN and where private operators do not intend to build them. The plan indicates the necessary preconditions facilitating investment in VHCN as well as defining strategic procedures for the construction of these networks and, at the same time, provides direct support from public sources while minimising interference in the market. The National Plan for VHCN estimates an investment gap for backhaul and access networks at CZK 15.3 billion (0.53 billion GBP). Based on the 75% co-financing rate, the planned public support is circa

CZK 11.5 billion (0.4 billion GBP) (European Commission. Broadband in the Czech Republic).

Use of funds from several funding sources is foreseen, including a number of EU funding streams: Integrated Regional Operational Program (IROP) 2021-2027, Connecting Europe Facility Program (CEF 2), Digital Europe Programme, Just Transformation Fund (JTF), InvestEU and Recovery and Resilience funding. (European Commission, Broadband in the Czech Republic, website accessed 23/02/2022)

Evidence of the cost effectiveness of different models

The government undertook regular, systematic evaluations of the Digital Education Strategy to 2020 to monitor progress. An interim evaluation in 2019 reported that significant progress had been made in the area of innovation. Stakeholders in the public, private, and non-profit sectors worked collaboratively to promote innovation in education through forums such as the Digital Coalition, established in 2016. The strategy analysed data on schools' use of digital technologies and their impact. Progress has been made in providing support for the integration of digital technologies in schools. At the same time, the report noted several delays largely due to a lack of financial or human resources and highlighted the important contribution of EU funds. There is also the challenge of digital education not always being seen as a priority among stakeholders (OECD, 2020, 2021).

Initial evidence suggests that pre-existing resources in the education system facilitated areas of the Czech Republic's early response to the COVID-19 pandemic. In particular, according to OECD (2020), the Digital Education Strategy to 2020 had a positive impact on students' digital skills and may have helped facilitate distance learning.

Denmark

Summary and gaps

Denmark operates a highly decentralised system of schools, with a great deal of autonomy at municipal level for primary and lower secondary schools and at school level for upper secondary and beyond. Funding, which comes either directly from the government for upper secondary or from municipalities, is largely allocated on the basis of pupil numbers and socioeconomic factors. There is very little in the way of funding for specific initiatives.

A number of overlapping digital strategies, action plans and initiatives co-exist, with education-specific strategies largely expanding on aims outlined in wider digital strategies. Although national strategies are developed with wide stakeholder involvement, it is recognised that regional, local and school level strategies need to be drawn up to adapt to local circumstances for implementation. That said, it is not clear to what extent the national government is able to exert leverage on schools to meet these aims other than through national curriculum requirements when it comes to the teaching of technology.

The national offer largely relates to the digital portal and collaboration platform for teachers, students and parents, as well as a nationally supported platform for accessing learning resources.

There is little evaluation of any of these initiatives in the Anglophone literature, with the exception of the 2012 -2017 Digital Strategy for Schools which did not have a focus on cost-effectiveness. Given the highly devolved nature of any expenditure on digitisation, it is unlikely that such evaluations would, in any case, be feasible.

Overview of school system

Education is compulsory between the age of 6 and 16. Compulsory education consists of 10 years of primary and lower secondary education, including 1 pre-school year (form 0) and 9 school years (forms 1-9).

The Danish Folkeskole covers primary and lower secondary education until pupils are aged 16. As an alternative to the Folkeskole, a number of private schools exist, that are supported financially by the Danish Ministry of Education. Publicly funded private schools receive public grants including operational grants, special grants, block grants and building grants. The grants received for operational expenditure are based on a per pupil per year formula that corresponds to that in municipal primary and lower secondary schools (folkeskolen) less the fees paid by the pupils' parents. Grant conditions are that the school must have a certain degree of self-financing, be of a minimum specified size and ensure that teaching meets the same requirements as for state schools.

Upper secondary institutions cover general and vocational upper secondary education. Generally, students start upper secondary education at age 16. The main pathways are:

- General upper secondary education programmes offered at general upper secondary institutions. Generally, the students attend the programmes when they are 16 to19 years old.
- Vocational education and training programmes offered at vocational colleges. The age distribution and the grouping of students depends on the individual VET programme. The average age of students starting on a VET programme is 24 years. Generally, the programmes are completed after 3 to5 years (Eurydice 2021a).

There are around 1500 primary/lower secondary schools, 175 upper secondary (Gymnasiale uddannelser) and 89 vocational schools (Finn Togo, 2019).

Funding

The education system is financed by the state and the municipalities. Some institutions, including the upper secondary education institutions, are independent and self-governing, while others are owned by the state or the municipalities (all primary and lower secondary are funded by the municipalities).

The central government's system of financing education and training is almost exclusively based on the so-called taximeter system, a comprehensive financing system based on per capita grants to institutions. All schools funded by central government receive their grants based on various taximeter systems adapted to the different types of upper secondary and vocational schools. (Ministry of Higher Education and Science website; Eurydice, 2021d).

As municipal schools, the Folkeskolen are not financed from the taximeter system. Approximately 71% of municipal revenues are from local tax income, while central government grants account for 26%. Expenditure on children and young people accounts for 26% of municipalities' total spending. Few central government grants are earmarked for education specifically, and these are modest. National education funds are allocated largely according to an assessment of municipal need based on the population aged 6 to16 and socioeconomic conditions such as unemployment, educational attainment and housing (Ministry of Higher Education and Science website; Eurydice, 2021d; OECD, 2020).

Brief description of digital strategy

There are a number of digital strategies and action plans, often with overlapping timescales, some of which relate to the public sector as a whole but include aspects of education, others of which are education specific. In brief, these are:

- Digital Strategy 2016–2020: A Stronger and More Secure Digital Denmark
- Strategy for Denmark's Digital Growth (2018)

(These are both broader strategies with themes that include boosting trade, effective public services and digital skills for all. The latter includes the role of schools, education and training.)

In terms of school specific strategies:

- 2012 -2017 Digital Strategy for Schools
- Digital development plan for the primary and lower secondary school 2015
- Action Plan for Technology in Education, February 2018
- New trial programme: Mandatory "teknologiforståelse" primary/lower secondary school (technology comprehension)

Priorities and timescales

There seems to be a wide range of digital strategies, with often overlapping timescales, operating in Denmark over the last 20 years. Some of these are broader but include schools whereas others, strategies and action plans, are education specific. These are listed below, together with a broad indication of coverage.

Broader strategies

Digital Strategy 2016–2020: A Stronger and More Secure Digital Denmark

The strategy sets out 3 main goals, supported by focus areas:

1. Digital solutions must be easy to use, quick and ensure high quality. Focus areas are: a user friendly and simple digital public sector; better use of data; more cohesive welfare services.
2. Digitisation must provide good conditions for growth. Focus areas are: better framework for the business community; public sector data as a driver for growth; efficient utilities sector.

3. Security and confidence must be in focus at all times. Focus areas are: public sector protects data; robust digital infrastructure; digitisation for everyone (within this sits digital skills for children and young people).

The Digital strategy stated that "Children and young people should benefit from digital learning tools and materials that enhance teaching. Before the end of 2018, the effect of efforts to apply ICT in teaching in municipal primary and lower-secondary schools will be measured. There will be efforts to support the implementation of the agreement that pupils, parents, teachers and child carers have a shared user portal as their digital access point for learning materials, communications and other information regarding the teaching in primary and lower-secondary school. In 2019, all relevant upper-secondary written exams will be digital, and in 2020 all relevant written primary and lower-secondary school leaving exams will be digital" (Agency for Digitisation, 2016). It is not clear if this remains the case.

Strategy for Denmark's Digital Growth (2018)

The main initiatives in this strategy are:

Digital Hub Denmark. Establishing a public – private partnership to support new business models.

1. A technology pact between trade, industry and education to provide initiatives aimed at strengthening the technical and digital skills of the Danish people.
2. SME Digital to support the digital enhancement of smaller enterprises and assist e-commerce.
3. A four-year pilot scheme to gather information about the best way to strengthen technological understanding in students and make technological understanding a mandatory subject in primary and lower secondary education, as well as equipping schools for the initiative by developing the skills of teachers.
4. Work to enable Danish companies to be among the best at utilising the potential of data-driven business development.
5. More agile regulation that permits businesses to experiment with new business models new business models. (Ministry of Industry, Business and Financial Affairs, 2018)

With regard to young people, the focus on digital competences is particularly relevant. The strategy initiates:

- A technology pact with the participation of public and private partners with the purpose of increasing the number of people interested in science, technology, engineering and mathematics (STEM), with STEM education, and with STEM employment.

- A four-year research project on technology understanding in primary and lower secondary education.
- The introduction of a new optional course, Technology Understanding, in lower secondary education.
- The use of digital technology in vocational education and training (VET).
- The use of digital technology in adult and continuing training. (EACEA website accessed 11/1/22)

Education strategies and action plans

2012 -2017 Digital Strategy for Schools

Government responsibilities:

- Public infrastructure through UNI-Login (single sign on solution)
- Public IT-standards to ensure communication and data transfer

Municipalities responsible for:

- Wifi and hardware
- Learning management systems (2017)
- Cooperation platform (Aula) in 2019 (Finn Togo, 2019)

Digital development plan for the primary and lower secondary school 2015

An agreement between the central government and the National Association of Local Authorities (KL) on local government finances in 2015 included a joint digital development plan for the primary and lower secondary school. The agreement contained the following elements:

- A common public infrastructure
- A municipal procurement of local IT systems
- Establish a set of common public standards for technology in schools

Schools access the User Portal through procurement by the municipalities which are responsible for all procurement of IT solutions. All primary and lower secondary schools were provided with a learning platform at the end of 2017, and from August 2019, the joint municipal communication and collaboration platform Aula was made available to all schools (Agency for IT and Learning, website accessed 11/1/22).

Action Plan for Technology in Education, February 2018

This has five priorities:

1. Technology understanding for all children, young people and adults

2. Digital skills of teachers, managers and educators

3. Use of IT in education

4. User-friendly digital infrastructure and learning resources

5. Use of data and data ethics

Four-year test programme: Mandatory “teknologiforståelse” primary/lower secondary school (technology comprehension)

This has the following features:

- Program duration: 2018 to 2021
- Focus on programming (computational thinking), consequences of technology and automation on society, design and innovation, problem solving, digital competencies (i.e., social media)
- Development of teacher competences
- 40 to 50 participating schools

Is there funding attached to strategies/initiatives and how is this devolved?

Between 2012 and 2017, DKK 500m (Approx. 56m GBP) of government funding was provided to support digitisation in primary and lower secondary schools and this was primarily spent on supporting municipalities’ investments in digital learning resources (50% of cost) and research (Finn Togo, 2019). It is not clear what the definition of ‘learning resources’ includes.

The four-year test programme has been allocated a budget of DKK 68 million (7.6 million GBP) for 2018–2021 (Ministry of Industry, Business and Financial Affairs, 2018). It is not clear from the literature how this is devolved.

Beyond this, it is assumed that funding decisions, including those related to digitisation, are made at municipality and school board level, albeit with input from the school head.

Does the strategy provide a rationale for the level at which decision making to support the digital strategy and associated funding is delegated? (NB: this should also include relevant information on school/local autonomy in the country and the levers available to support strategy implementation)

The Digital Strategy 2016-2020 was presented as a strategy developed jointly with the businesses and public institutions at local, regional and central-government levels. It also makes the point that, in parallel with joint public sector efforts, there are sector-specific digitisation projects and strategies, for example joint municipal and regional digital strategies. It argues that this approach to public sector digitisation efforts provides "a good balance between common strategic targets and local adaptation and priorities" (Agency for Digitisation,2016).

The Ministry of Industry, Business and Financial Affairs is the responsible authority for the 2018 Strategy for Digital Growth in Denmark. Besides the Minister for Industry, Business and Financial Affairs, a team of ministers is involved in the implementation of the strategy: the Minister for Higher Education and Science, the Minister for Children and Education, and the Minister for Employment. The team of ministers is responsible for ensuring progress in the implementation of the strategy and for hosting an annual summit for the strategy where the government reports on the status for the implementation of the initiatives. (EACEA website accessed 11/1/22)

In respect of education, Denmark has a highly devolved approach to funding and decision making: "Danish education is highly decentralised between early childhood education and care (ECEC) and upper secondary. School autonomy levels are high, and municipalities have extensive responsibilities in primary and lower-secondary schooling. Policy-making therefore depends heavily on the ability of different actors to collaborate and co-ordinate effectively" (OECD, 2020).

At the central level, the Ministry of Children and Education is responsible for early childhood education and care (ECEC), primary and lower secondary education (Folkeskolen), upper secondary education, vocational education and training, adult education at ISCED level 2-3 and non-formal adult education. The National Agency for IT and Learning, which is responsible for digital learning and IT solutions in the education, is overseen by this ministry. The Ministry of Higher Education and Science is responsible for higher education (ISCED level 4-7), science and innovation.

National legislation covers the aims and framework of education, funding and in some cases curricula, examinations and staffing. The Ministry of Education is responsible for setting up the framework for curricula at primary and secondary level. However, the contents of the courses are finalised by the teachers themselves, with their pupils. The

Ministry of Education oversees the municipal primary and lower secondary schools in collaboration with the municipal councils.

The five regions a have a limited number of responsibilities in relation to education:

- Coordinating the general and vocational upper secondary education activities in the region
- Coordinating responsibility of adult education in the region
- Investing in quality development of adult and upper secondary education

The 98 municipalities are responsible for securing early childhood education and care (ECEC) and municipal primary and lower secondary education. They also employ teachers and school heads (Ministry of Higher Education and Science website; Eurydice, 2021b). The municipal councils have the right to delegate authority to the head teacher and the school board within specific areas which include proposing the curriculum and allocation of the school budget. The school board conducts its activities within the target and framework laid down by the municipal council, and supervises the school's activities. The school board comprises teacher, parent and pupil representatives. The responsibilities of the school board include:

- Approval of the school budget
- Drawing up the rules of conduct of the school
- Drawing up a proposal for the curricula for submission to the municipal council

General and vocational upper secondary schools are self-governing institutions, meaning that the institutions have an independent board. At vocational upper secondary schools, representatives from employer and employee groups must be represented among members of the board. At upper secondary level, the board is responsible for:

- Deciding the school's education supply, activities and capacity
- Ensuring there is a suitable head teacher/management
- Approving the school's budget and financial framework (Eurydice, 2021c)

What evidence is there of approaches/initiatives instead of, or in addition to, a digital strategy?

Municipalities and schools are encouraged to develop their own digital strategies, adapting national priorities to meet local needs (Finn Togo, 2019).

Which bodies take decisions about spending in the delivery chain from government to individual schools and colleges?

Primary and lower secondary

Municipalities decide upon the system of financing for schools under their responsibility; however, the Ministry of Education has laid down certain minimum requirements in terms of class sizes; curriculum etc.

Upper secondary and vocational schools

The main idea behind taximeter approach is that decisions with regard to the implementation of educational programmes are best taken by the heads and boards of the educational institutions. A key element in the taximeter system is the block grant principle. As long as the block grant is used for legitimate purposes, the institution is free to spend the money in accordance with its own priorities (Ministry of Higher Education and Science website; Eurydice, 2021d).

Overview of bodies taking decisions about technology choices

Digital strategy for Growth: the Ministry of Industry, Business and Financial Affairs is the responsible authority for the strategy. Besides the Minister for Industry, Business and Financial Affairs, a team of ministers is involved in the implementation of the strategy: the Minister for Higher Education and Science, the Minister for Children and Education, and the Minister for Employment. The team of ministers is responsible for ensuring progress in the implementation of the strategy and for hosting an annual summit for the strategy where the government reports on the status of the implementation of the initiatives.

The joint public infrastructure is established in close cooperation between the state and KL (the association of municipalities), which also jointly develops the public data standards.

The Danish Agency for IT and Learning (STIL) develops and operates common IT infrastructure such as UNI-Login and STIL's integration platform. Common public standards set by government require that the Agency must ensure easy and secure access to the school's digital solutions, exchange data between IT systems and ensure good competition in the IT market for IT solutions for primary and lower secondary schools. The parts of the joint public infrastructure that the individual school comes closest to are an expansion of the UNI-Login function as well as an integration platform that enables the use of data from the ministry's national services in the municipal learning platforms and the collaboration platform, Aula. KL and the municipalities' IT community, KOMBIT, are responsible for the programme management of Aula.

The Agency for IT and Learning is advised by a panel which meets 2 to 3 times a year. The panel is composed of members from across the education sector and gives stakeholders the opportunity to formulate needs and wishes for the agency.

Specific decision areas (centralised or devolved) and links to strategies and funding

Broadband connectivity

The central government, regions and municipalities have agreed, through the Digital Strategy 2016-2020, to aim at 100 Mbps download and 30 Mbps upload speeds for all households and organisations by 2020 (it is not clear if this has been achieved or how this is funded).

Digital infrastructure (including Wi-Fi, switching and cabling, servers and cloud storage and internal networking in school/college buildings)

Digital infrastructure within schools is the responsibility of the municipalities.

Data (interoperability, security)

See AULA and Uni-Login below. The Centre for Technology and Data is responsible for forging a more coherent public sector by providing an improved framework for sharing and reusing data and new technological opportunities. The centre is responsible for preparing, coordinating and implementing work on data and new technology in the public sector. This includes ensuring interoperability between work on basic data and common public sector digital architecture. The centre is also responsible for a number of initiatives based on the common public sector Digital Strategy 2016-2020 and the government's Coherency Reform track towards world-class digital service, including common public sector digital architecture, the Basic Data programme, and strategies for data and AI(Agency for Digitisation website, accessed 12/1/22).

Back-office systems (the software that supports the technology)

Uni-Login is the digital infrastructure that connects pupils, teachers, parents, the school and digital learning resources. It provides access to almost all digital resources in the school:

- digital learning resources
- the school's intranet
- internet and Cloud services
- the school's computers and Wi-Fi

In 2018, there were more than 1 million registered users (pupils, parents, teachers, school leaders) and more than 20 million logins per month, equivalent to an average one million logins per school day (Finn Togo, 2019). Procurement of access to Uni-Login is the responsibility of the municipality for primary and lower secondary schools.

According to the Agency for IT and Learning, “all pupils, parents, pedagogical staff and school leaders must experience a coherent digital primary and lower secondary school through a common public infrastructure and local IT systems - digital learning platforms and the collaboration platform Aula. That is the purpose of the User Portal Initiative.”

The aims of the portal are:

- For students, the initiative must ensure that they can work digitally and have access to digital tools and teaching aids, receive information about their own learning and have the opportunity to communicate with their teachers and finally that they can share material with group peers.
- For parents, the initiative must ensure that they can get an overview of their child's school day, that they can support the child's learning and follow the child's professional and well-being development.
- For teachers and other pedagogical staff, the initiative must ensure that they can work digitally to plan, implement and evaluate learning processes based on common goals, for example, and that they can share knowledge with their colleagues and communicate with students and parents about student academic progress and well-being

It was agreed in November 2018 that a new direction must be set for the learning platforms based on the recommendations of the Working Group on Common Objectives from June 2018. The five themes of the recommendations, which were included in a supplementary agreement, are:

- Theme 1: Need for strengthened local dialogue on the meaningful use of learning platforms
- Theme 2: More room for professional judgment and for experimental approaches to learning platforms
- Theme 3: The design of the learning platforms must support a flexible application
- Theme 4: Rethinking the student plan function on the learning platforms
- Theme 5: The development of technologies to support the work of professionals

Aula is a collaboration and communication platform between school and home to support children's learning and well-being through good communication between teachers, educators, children and their parents (Agency for IT and Learning, website accessed 11/1/22). It was developed centrally and forms part of the digital portal offer.

Accessibility (for example, audio visual)

No information found.

Hardware (for example, laptops, desktops, tablets, peripherals)

Danish schools use different strategies:

- The school provides the students with a device (laptop/tablet)
- The school provides a number of devices, shared between at least two students
- BYOD – the students bring their own device with the school or municipality providing a device for those who cannot bring their own

Access to computers at home in Denmark is high – 98% of those in lower socioeconomic groups have access to at least one computer at home (Finn-Togo, 2019)

Software (for example, Management information systems, HR, finance, safeguarding, monitoring and filtering)

This seems to be a matter for schools/municipalities, excepting where some aspects may be covered through Uni-Login and Aula.

Curriculum and business administration choices

A general upper secondary reform introduced digital competencies in all relevant subject curricula in general upper secondary educations from the school year 2017/18. From the school year 2017/2018, a new optional generic subject, Informatics, has been implemented. Informatics is a mandatory part of other subjects but can also be both mandatory or optional as a separate subject, depending on the line of education.

The four-year test programme and its evaluation will form the basis for decisions as to how technological understanding can be made a mandatory part of primary and lower secondary education, as an independent subject and/or via integration with certain existing subjects (Ministry of Industry, Business and Financial Affairs, 2018).

In addition, the Materials Platform, developed and maintained by the Agency for IT and Learning, is a national online catalogue that contains descriptions of all types of teaching aids for use in the education sector including both analogue and digital materials. The materials can be purchased or picked up free of charge directly from the individual publisher or manufacturer. This means that, although the platform was developed centrally, the materials it links to may be free to schools or may need to be paid for.

Staff training A key aspect of the four-year test programme is looking at the skills needs of teachers and a decision will be made as to whether an entirely new subject or discipline regarding technological understanding should be developed (Ministry of Industry, Business and Financial Affairs, 2018).

Technical support

The Agency for IT and Learning offers technical support to schools for its systems, portals and services as well as guides and links.

In schools owned by the municipalities all staff, including technicians, are employed by the municipality who allocate funding and approve budgets submitted by the school boards which would presumably include technical support needs, whether through the direct employment of a technician or, potentially, outsourced. It is also possible that municipalities may offer technical support to their schools but the extent to which this happens, if at all, is not available in the Anglophone literature. Other schools are self-governing and would make those decisions at board level. See above for details on funding and decision making.

Cyber security

The Danish Government, under the auspices of the Agency for Digitalisation has published the Danish cyber and information security strategy 2018–2021. To ensure that society can continue to benefit from technological opportunities and that citizens can retain confidence in digital development the government will invest 1.5 billion DKK (168m GBP) in cyber and information security from 2018 to 2021. The strategy sets out a number of initiatives including a cyber situation centre, improved national ICT infrastructure, digital judgement and competencies acquired via education, increased collaboration with sectors and internationally.

As part of the national cyber and information security strategy, teaching materials were made available for all levels of education (primary, preparatory basic training and education, vocational and general upper secondary, and vocational adult education training). The teaching materials include lesson plans and activities and deal with media literacy and resilience toward fake news, hacking, echo chambers, and radicalisation (EACEA website accessed 11/1/22)

How (and by how much) infrastructure is funded, and how this investment is supported and delivered

The Danish Government, through the Digital Growth Strategy, set a target that by 2020 all households and businesses must have access to a broadband connection with a download speed of at least 100 Mbps and upload speed of at least 30 Mbps. The point of departure of the government is that broadband development should be market-driven, and regulation should be technology-neutral. In order to promote this development and ensure good broadband coverage throughout Denmark, the government took a number of initiatives:

- Establishment of a test scheme with a government broadband funding pool of DKK 200 million (22.5 million GBP)
- Better opportunities to utilise existing passive infrastructure for broadband such as empty underground pipes and conduits
- Ambitious requirements for coverage in future frequency auctions
- The BoligJobordning (tax deduction scheme for domestic and home-improvement services) can be used for the deployment of broadband.

The Agency for Digitisation is an agency of the Ministry of Finance and was established in 2011 to speed up the digitisation processes required to modernise the Danish welfare society. The Agency is in charge of the digitisation of Denmark and is responsible for the implementation of the government's digital ambitions in the public sector.

Denmark’s primary focus is on the roll-out of high-speed network infrastructure based on private investments. A key role is reserved for municipalities in coordinating and promoting the process in cooperation with telecommunication operators. Public funding is reserved for areas with poor broadband coverage. The Broadband Fund, administered by the Danish Energy Agency, provides support to close the connectivity gap of the estimated 6% of households and/or companies that still do not have high-speed-internet access. The government has provided DKK 100 million (11.25 million GBP) yearly since 2018 to support households and firms with poor broadband coverage. The Danish Government is currently developing a new broadband strategy (European Commission, Broadband in Denmark, website accessed 23/02/2022).

Evidence of the cost effectiveness of different models

There are no studies available in English that looked at cost-effectiveness (this may be because implementation and funding is too decentralised for this) but a government publication (Digitalization with Thought and Vision, March 2019) outlines the current status of the use of digital technology in schools and challenges. The publication is based on research results, status reports, surveys and workshops with teachers, pupils, head teachers and stakeholders. It identified four themes:

1. The use of technology and digital products in the teaching situation. A need to focus on quality/effect.

2. The effects of technology on the health and well-being of children and young people.
3. Understanding technology and teaching students in the application and development of and approach to technology.
4. Ensure efficient IT infrastructure in schools and access to digital tools, for example wifi and devices.

It also identified the following challenges:

- Mixed evidence on the effects of the use of digital technology on learning and a lack of research on this in Denmark.
- What should the policy be on the use of mobiles/tablets in schools?
- GDPR compliance and data ethics.
- Teachers’ IT competencies.
- Quality of learning resources.
- Teachers (and their trainers) lack the depth of knowledge to improve pupils’ technology comprehension (Finn Togo, 2019).

In addition, an evaluation of the 2012 -2017 Digital Strategy for Schools conducted by the Ministry of Education in 2018 strategy found:

- Digital learning resources: 86% of school leaders saw a positive development in the quality of digital learning resources within the previous five years, and 83% saw positive developments in the supply of digital learning resources. They also saw a trend of increasing centralisation of purchasing by the municipalities.
- Applications: more than 80% of teachers use digital resources as much as possible when they teach. Most teachers use IT in combination with analogue resources. Teachers/pupils generally experience positive effects, for example, in terms of teaching differentiation and motivation.
- Infrastructure: the proportion of teachers who experience practical and technical challenges with accessing digital resources decreased from 22% in 2014 to 12% in 2018.
- Learning platforms: mixed experiences. Among the most digitally confident teachers 50-75% experienced positive effects.
- Perceived pedagogical effect: teachers reported positive pedagogical effects, especially regarding differentiated teaching and motivation.
- Almost half of schools (46%) reported having a digital strategy in place (Finn-Togo, 2019).

Estonia

Summary and gaps

Estonia continues to outperform other countries in overall PISA (Programme for International Student Assessment) performance despite relatively low expenditure on education (OECD, 2020) which has made it of interest to policy makers.

Estonia prides itself on being a digital society where much of public life involves digital access; the high degree of digital use in education (digital textbooks, e-assessments and e-diaries, for example) need to be viewed in that context.

Estonia, the Baltic nation of just 1.3 million people has attracted the attention of world leaders, academics and venture capitalists thanks to its high-tech digital society. The numbers speak for themselves: taxes are completed online in under 5 minutes, 99% of Estonia's public services are available on the web 24 hours a day and 99% of schools had already before the COVID-19 been using some type of e-solutions. Education Estonia (an initiative for international education cooperation by the government of Estonia) website.

At the core of Estonia's digital transformation is the idea of a digital citizen who accesses public and private services through a digital platform that ensures the interoperability of diverse and decentralised information systems. "Two elements were essential: first, the adoption by politicians and policy-makers of a culture of risk-taking and bold ideas; and second, the formation of multiple overlapping small networks to promote early success and build momentum" (Kattel and Mergel, 2018). In Estonia, these phenomena became mutually enforcing and enabled the rapid adoption of innovative solutions, albeit guided by clear design principles.

This diverse approach to development of digital solutions, involving as it does the public and private sectors, make it difficult to determine levels of funding and how such funding is devolved, although it is clear that EU funds have played a not inconsiderable part. Local and school autonomy too is an important part of education in Estonia, meaning that digital decisions are often taken at school level even where there is a central offer, although the state has levers open to it such as the training of teachers and the overarching curriculum.

Overview of school system

Compulsory education in Estonia begins at age 7 and finishes at the end of what is known as 'basic' school, usually at the age of 16; However, pupils are required to stay in education until they achieve the school leaving requirements or until 17 years of age.

Completion of the school curriculum and passing three final examinations of basic school is a condition of graduation from the basic school. Students are first tracked into different educational pathways at the age of 16. Upper secondary education includes general education, which lasts three years, and vocational education, which can last up to four years (OECD, 2020; Eurydice, 2021a; Eurydice, 2021b).

While most pre-primary and general schools are owned and run by the municipalities, most vocational schools are state-owned. This means that 83% of schools are municipally owned, 6% are state schools and 11% are private schools. (OECD, 2020; Eurydice, 2021c).

Local government at municipal level has primary responsibility for school placements, attendance and the staffing, finance and maintenance of schools. At school level, a board of trustees submits proposals and budgets to the executive body of the municipality (in state-owned schools, a school council performs this function under the auspices of the Ministry of Education and Research) (OECD, 2020, Eurydice, 2021c). Schools have a large degree of autonomy.

Funding

Despite above-average outcomes in PISA, Estonia spends a below-average proportion of GDP on education compared to other OECD countries (4.4% compared to an average of 5%). However, recent increases in teachers' salaries are expected to lead to increases in overall education spending. At the same time, the modernisation of the school network has largely been completed, meaning that spending on infrastructure is likely to decline. However, historically, Estonia has received significant funds from the European Development Fund and the European Social Fund. An allocation of funding ended in 2020 and the OECD highlighted the challenge of finding new funding sources for activities currently supported by EU funding (OECD, 2020). However, it would appear EU funding is anticipated to support the new strategy.

For primary and secondary education, municipalities receive a national government grant based on four earmarked components: study materials, school lunches, professional development, and teacher and school leader salaries. Teacher salary allocations are based on a per-student formula, adjusted to provide sufficient funding to smaller municipalities. The minimum rates of teachers' salaries are established at the national level. Municipalities decide on how to allocate funding to individual schools, and schools have a high level of autonomy over their budgets. They can also raise additional funds through donations, parental contributions, and rental of facilities. Most Vocational Education and Training (VET) schools are owned by the national government and are funded through the state budget. Estonia moved towards a performance-related funding formula for VET in 2020. Recent reforms aimed at promoting school choice have led to an increase in the number of private schools in Estonia. From 2018, the state pays operating expenses support to the owners of private schools to the extent of 100 percent of the average operating expenses of municipal schools, with additional funding coming from fees (Eurydice, 2021c; OECD, 2020).

Brief description of digital strategy

There is no single digital strategy nor an education strategy restricted to schools. However, there are two education strategies that cover early learning and adult education and training, as well as schools, and which also encompass objectives relating to the use of digital technology in schools:

The Estonian Lifelong Learning Strategy 2020 was approved by the government in 2014. Details are given below.

The Estonian Education Strategy 2021–2035 (adopted in November 2021 by the government) is the basis of priority setting and funding decisions, and for the development of implementation programmes that support the achievement of strategic goals. The Education Strategy plays an important role in achieving the general objectives of the national long-term development plan ´Estonia 2035´. The overall objective of the strategy is "to equip the population of Estonia with the knowledge, skills and attitudes that prepare people to fulfil their potential in personal, occupational and social life and contribute to promoting the quality of life in Estonia as well as global sustainable development."

The overall objective is underpinned by three strategic goals:

1. Learning opportunities are diverse and accessible, and the education system enables smooth transitions between levels and types of education.
2. Estonia has competent and motivated teachers and heads of schools, a diverse learning environment and a learner-centred approach to learning.
3. Learning options are responsive to the development needs of society and the labour market (Eurydice, 2021e).

Priorities and timescales

Estonia does not have a separate digital strategy for schools; rather, they have had a broader approach to digitisation across the whole public sector for some time which does not result from a single, unified strategy or sequence of strategies. Nor does Estonia have a central office with responsibility for digital transformation. It has been argued (Kattel and Mergel, 2018) that Estonia's digital transformation has resulted from a number of ad hoc and informal developments; policy documents that have followed the rhythms of European (structural) funding periods; and various overlapping and mostly self-managed public-private networks have provided the informal dynamic capacity for transformation.

Below we set out some of the stages, approaches and initiatives that have led Estonia to its current position of pride in being a digital society (Education Estonia website, accessed 13/1/22).

Estonia's digital transformation started in the early 1990s, when Estonia regained its independence and has been characterised by widespread cross-party support. The aim is for public digital architecture that is universal in nature and empowers citizens but with decentralised digital agendas of the ministries: "government ICT projects could not afford to build massive systems run by large vendors. Instead, the government was encouraged to embrace a distributed architecture of IT systems to cater to the different needs of each government agency. This became an explicit strategy from 1999 onwards: ministries were asked to build their IT systems according to their specific needs, but ensuring frugality and interoperability across government" (Kattel and Mergel, 2018). This approach required a mechanism by which these distributed systems could exchange data with each other. This led to the development of 'x-road' as a layer for secure data exchange. This was followed by digital signatures and e-ID for citizens.

Funded both by public and private sector organisations, the Tiger Leap programme from 1996 aimed to bring all Estonian schools online and put computers in every classroom, achieved by 2000 ((Kattel and Mergel, 2018; Education Nation website). Over time, the education system has introduced digital databases, digital textbooks, e-learning materials, digital class diary and digital assessments (Education Nation website).

The reform of the national curriculum for basic and upper secondary schools (2014) set out eight competencies that should be developed throughout a young person's education. An action plan for the development of new syllabi in 2016 and for an update of the core curriculum in 2018 included new syllabi for ICT and entrepreneurship at lower and upper secondary level (OECD, 2020). However, Estonian teachers report a greater need for additional training in ICT and insufficient level of digital skills compared with other EU countries, and see this as a major obstacle to teaching digital skills. They also report difficulties in creating digital content (EC, 2019).

Estonia has, in the last decade, developed two educational strategies – the Lifelong Learning Strategy 2020 and its successor, the Estonian Education Strategy 2021 –2035. While covering the whole education and training landscape, these strategies do set out aspirations and approaches to the use of digital technology in schools.

Lifelong Learning Strategy 2020

This covered the years 2014 to 2020 and outlined five strategic goals for the entire education system:

1. Change in the approach to learning: Implementation of an approach to learning that supports each learner's individual and social development, the acquisition of learning skills, creativity and entrepreneurship at all levels and in all types of education.
2. Developing competent and motivated teachers and school leadership.
3. Alignment of lifelong learning opportunities with the needs of the labour market.
4. Placing a digital focus on lifelong learning: Improving the digital skills of the population, for example, by upgrading the digital infrastructure of schools and higher education institutions and incorporating a digital culture into the learning process.
5. Ensuring equal opportunities and increased participation in lifelong learning.

The implementation process entailed cross-level collaboration and included a digital transformation programme with the aim of developing the digital competencies of both teachers and students (OECD, 2020; Eurydice, 2021b).

The Education Strategy 2021–2035 is a follow-up plan to the Estonian Lifelong Learning Strategy 2020. Key goals of the strategy include providing more flexible pathways for learners, promoting Estonian language and culture, a focus on skills development and collaborative processes in learning, and improving the quality of higher education and research. In spring 2018, the Ministry of Education and Research (MoER) commissioned groups of experts to create vision papers in the fields of education, research, youth and language for the years 2021–2035. The vision papers focused on three themes: values and responsibilities; prosperity and cohesion; and competitiveness. Stakeholders and the wider public have been involved in the strategy development through an e-consultation process (Eurydice, 2021d; Estonian Ministry of Education and Research, 2019).

According to the MoER, the vision is that:

"The future education system must "produce" technologically literate people that implement and create new opportunities for social development and are familiar with modern methods of data collection and analysis. New technologies are acquired as separate skills and as integrated into other subjects... In a technology-rich and individualised learning environment, the teacher's work becomes data-based… the teacher can monitor student progress, provide personal feedback, and guide further action. To be able to operate successfully in a technology-rich seamless educational space, the teacher is assisted by educational technicians and educational logistics if necessary. Teachers' reporting burdens are reduced through e-solutions" (Estonian Ministry of Education and Research, 2019)

However, at this stage only vision papers for each domain are available in English and it is not known if the visions are accompanied by concrete proposals and timelines yet.

Is there funding attached to strategies/initiatives and how is this devolved?

Because of the diffuse nature of the use of digital technology in Estonia over the last thirty years, the involvement of private sector funding and that education was seen as part of a much broader process of transformation, it has not been possible to identify funding related to particular strategies.

The Tiger Leap programme can be seen as a blueprint for how digital transformation was delivered (Kattel and Mergel, 2018). The programme was initiated in 1996 through a legally private foundation in which government was one of the founding members and key funders, alongside 11 IT companies. It created competitive grants and encouraged schools and local governments to submit applications for the rather limited government funding for IT education programmes. "Above all, such fluid structures allowed private actors, notably banks, to be heavily engaged in the Tiger Leap programme. Importantly, foundation-based structures allowed public-private networks to operate outside of government without much red tape – and without much institutionalisation or formalisation" (Kattel and Mergel, 2018).

Eurydice (2021b) notes that the Estonian Lifelong Learning Strategy 2020 was used as the reference point for educational budgetary decisions between 2014 and 2020 by municipalities and school owners. This presumably means that budgetary decisions were expected to be influenced by the priorities within that strategy.

For implementing the 2021-2035 strategy, Estonia anticipates making use of EU funds between 2021 and 2027 but it is not clear how much this funding will entail or how it will be allocated between the different objectives in the strategy. To ensure a more efficient use of school resources, Estonia plans to further address demographic trends within the student population and the teaching workforce, for example, by giving further incentives to reorganise the school network and reduce the number of basic schools in response to the falling birth-rate and addressing the high share of part-time work among teachers. Reorganising the school network, partly financed by EU funds, is ongoing and will require further investment in the coming years (European Commission, 2019). We could find no specific funding stream relating to the digital curriculum and raising the digital skills of teachers.

Does the strategy provide a rationale for the level at which decision making to support the digital strategy and associated funding is delegated? (NB: this should also include relevant information on school/local autonomy in the country and the levers available to support strategy implementation)

Although Education is decentralised and schools have a large degree of autonomy, the state has some levers available to it. The state sets national standards (the national curriculum for preschool childcare institutions, the national curriculum for basic schools, the national curriculum for upper secondary schools, the national curricula for vocational studies, the standard of higher education and the standard of vocational education) and establishes principles of education funding, state supervision and quality assessment. The state also sets the framework for teacher training (OECD, 2020, Eurydice, 2021c).

As far as the use of digital technology is concerned, ICT strategies are decentralised to ministerial departments although coordination and design principles are centrally set:

- No legacy principle: public digital infrastructure should not use technological solutions that are older than 13 years.
- Build versus buy principle: the priority is to build systems from scratch rather than buying 'off-the-shelf' software systems from ICT vendors (particularly true for Estonia in the early stages of digital transformation).
- Once only principle: businesses and citizens must supply information for government authorities only once and data is available across government agencies through the data exchange layer x-road.
- Interoperability and security principle: rather than seeking to create unified databases and information systems
- A deliberate focus on public-private networks rather than on individual organisations (Kattel and Mergel, 2018).

What evidence is there of approaches/initiatives instead of, or in addition to, a digital strategy?

The switch to distance learning saw a considerable increase in the use of digital platforms, including eSchool (2002), a school management service already used by 85% of schools, and E-Schoolbag (2016), which hosts educational resources quality-reviewed by subject experts (OECD, 2020).

According to Lorenz et al. (2017) the IT industry has supported schools to improve their use of technology, including:

- From 2009 onwards, Microsoft has run several projects under the aegis of their Partners in Learning programme.
- BCS Training has a Creative Classroom project that has been funded by Erasmus+ (amount unknown).
- Samsung Baltics started several projects in Estonia and Latvia starting from 2014, with the common idea to train six members of the school (including school leaders) who will proceed to innovate the rest of the school and community. Every year 8–12 schools are chosen for the full training programme and competition where the first prize is 10,000 euros (8,340 GBP). The programme content and training are provided by Tallinn University experts - professors, lecturers and researchers. At the end of every year, there will be a prize of 10,000 euros for one of the schools
- The SmartLab project that is funded by Estonian Association of Information Technology and Telecommunications runs small-scale projects focusing on robotics, coding and engineering education as extracurricular activities (degree of funding unknown).

As part of efforts to improve the digital competences of the population, Estonia has developed tools to assess the digital skills of students and to evaluate the digital infrastructure of schools. The Foundation Innove worked with researchers from the universities of Tallinn and Tartu to develop digital competency assessments (2019) for students in grades 9 and 12, and those in upper secondary VET. Students receive verbal feedback on their performance, and schools receive feedback on digital competencies at the school level (OECD, 2020).

At the school level, the Digital Mirror (2018) is a tool used to help schools to assess their digital maturity and develop an improvement plan. Some 449 general education schools were due to complete the self-evaluation process in 2019 (OECD, 2020).

Which bodies take decisions about spending in the delivery chain from government to individual schools and colleges?

The Estonian Government and the Ministry of Education and Research are responsible for education policy and overall strategy. The Ministry of Education and Research also has responsibilities in the areas of curriculum and funding. The Estonian Lifelong Learning Strategy (2012-2020) has provided the guiding principles for education policy development throughout the system (Eurydice, 2021b).

Municipalities have responsibility for monitoring attendance, hiring school leaders, establishing school supervisory bodies, and implementing county plans for educational development (OECD, 2020). The municipalities are also responsible for maintaining the schools' technical equipment and network connections and the extent to which they do this is variable. Some authorities have initiated competitions with prizes for innovative projects. The council of Tartu tested out 'open learning areas' and digital school implementations with assistance from EU funds (Lorenz et al., 2017).

Other bodies also have some input in spending decisions:

- The Innove Foundation develops and implements a range of external assessments such as national tests at the end of basic and upper secondary school. It also co-ordinates development activities and implements projects funded through EU structural support.
- Education departments within county governments supervise pre-primary and general education and often facilitate co-ordination between municipalities, and between national and local government. It is not clear whether they contribute to spending decisions.

In 2017, the share of key decisions taken by Estonian schools, at 58.3%, was among the highest in the OECD, where the average was 33.95%, giving school leaders a high degree of autonomy. In addition to leading teaching and learning, Estonian school leaders establish teachers' salaries (providing that they meet at least the minimum national rate), manage financial resources, and are responsible for quality assurance. In TALIS 2018, the share of school principals in Estonia who reported having a significant responsibility for deciding on budget allocations within the school was among the highest in the OECD (OECD, 2020).

Overview of bodies taking decisions about technology choices

For most schools, municipalities will have the responsibility for digital infrastructure in schools, although with considerable input from the schools themselves. Other decisions might be influenced by the municipalities (including through their budget allocations) but ultimately very often the responsibility of the schools. In vocational schools, the ministry is responsible for infrastructure with, again, the school through its board, recommending budget allocations at school level.

However, Lorenz et al. (2017) noted two problems in this approach in improving the use of digital technology: firstly, that municipalities may be unaware of the technology needs of specific schools and, secondly, schools' independence make any 'one size fits all' strategic approach is unlikely to succeed. The key is to allow schools to set their own goals and path to achieving them, getting as many staff on board as possible, and provide them with tools and support to succeed.

Specific decision areas (centralised or devolved) and links to strategies and funding

Broadband connectivity

All Estonian schools were provided with the internet in 2001 as part of the Tiger Leap programme and the state has provided funds for a high-speed Internet access, modern equipment and digital learning tools to reach the educational establishments (Education Nation). The level of funding is not available, nor the mechanism for distributing it; however, it seems likely funding has included some from the EU and is distributed through a mix of funding to the municipalities, to vocational schools directly and via agencies.

Digital infrastructure (including Wi-Fi, switching and cabling, servers and cloud storage and internal networking in school/college buildings)

Estonia's efforts to leverage technology for teaching and learning began in the 1990s with the Tiger Leap programme but government acknowledges that the infrastructure created two decades ago needs to be upgraded. Beginning in 2015 and lasting for five years, a modernisation programme for the physical infrastructure that connects Estonian schools to the internet began. With a cost of approximately 13 million euros (10.9 million GBP) allocated from the European Union Social Fund, once completed, schools will have network speeds of at least 1 Gbit/s and full Wi-Fi coverage in all classrooms with an ability to increase access speeds as required over the foreseeable future. A flexible solution that is modular and can adapt to the specific needs of both small and large schools was part of the requirements.

In 2016, a working group of network infrastructure experts and specialists sketched out a concept that was comprised of two tiers. The first tier dealt with physical connections – a fibre optic backbone inside the school connecting server rack cabinets ranging in size from 9U through 42U that would branch out into a CAT-6 cable network extending into every room that could require an internet connection. The second tier dealt with equipment – a full suite of networking equipment for stand-alone functionality (firewall, switches, Wi-Fi access points) that could be managed over a single management platform locally or centrally.

Over the course of 2017 a pilot project was initiated and the concept validated. During the second half of the year, large scale tenders for framework contracts were successfully concluded with a total of six cabling companies and one equipment provider and installer. By the beginning of 2019 more than 150 small and medium-sized schools had been modernised as the first phase of the project ended. The second phase of the project started as COVID-19 restrictions emptied schools around the world in March of 2020. As of spring 2021 modernisation works were concluded in another 70 schools.

Over the course of the project, a core team of about 10 people have managed the work of about 120 installation specialists and coordinated with roughly 350 officials in schools and local governments. It was then anticipated that this phase of work, with all schools' infrastructure modernised, will complete by the end of 2021. It is not clear if this has been achieved.

After all work in schools is complete, the project will wind down and transition into the analysis and planning stage currently expected to last until 2030. During that time dynamics of aggregate data flows as well as internet traffic will be monitored and as capacity issues arise planning for the next wave of modernisation will begin. A new working group will be convened that will plan for a future, where data flows are expected to exceed the capacity of fibre optic networks (Education Nation website).

Data (interoperability, security)

The Estonian e-government infrastructure and its success rest on two main pillars, both introduced in 2001, which essentially created a digital state and digital citizens: the data infrastructure x-road and a compulsory national digital ID. X-road is an interoperability platform for existing decentralised databases and a data exchange layer that can be used by public and private sector actors. It is independent of platforms and architectures, and provides secure interoperability for data exchanges and identification of trusted actors in digital service delivery. The digital ID makes it possible for citizens to be identified digitally and to use digital signatures. Together, x-road and the digital ID make it possible to digitally sign any contract, access any public service, order prescriptions, file taxes, vote and so forth. More than 2,300 public and private services use x-road, and the digital signature has been used almost 350 million times by Estonia's population of 1.3 million (Kattel and Mergel, 2018).

Back-office systems (the software that supports the technology)

HarID is a personal information and user account management system designed for educational institutions and is suitable for the administration of user accounts and integration with existing systems (Education Nation website).

Estonia also provides an environment for conducting national and school-based exams in an electronic format. E-Tests and the e-Assessment database EIS is linked to the Estonian Education Information system and data exchange platform X-Road.

The Student Admission System SAIS makes the application and admission process convenient by using data stored in public registers.

Accessibility (for example, audio visual)

No information found.

Hardware (for example, laptops, desktops, tablets, peripherals)

According to the Education Nation website, a 2013 ‘Survey of schools: ICT in education’, by European Schoolnet, found Estonian school students use of their own laptops and mobile devices in education to be above the EU average. In 2014, it was decided that BYOD – bring your own device - would be the Estonian way and there would be no big, country-wide device roll-outs. For students who do not own devices, there is always one set of commonly bought devices in schools.

“BYOD is seen as an example of efficient management of resources,” according to Estonia Future Classroom Lab’s Guide for School Leaders Estonian model. “The schools would like to make more use of technology but existing computer classrooms are insufficient and the schools lack funds to buy mobile devices for all students. Also, any devices purchased need replacing every two or three years. However, most students already own at least one device and, therefore, making educational use of these is seen as sensible. Also, the students are already in the habit of using their smart devices which is helpful.”

Software (for example, Management information systems, HR, finance, safeguarding, monitoring and filtering)

According to the Education Nation website, 95% of schools use e-school solutions (i.e. eKool, Stuudium which “provide an easy way for parents, teachers and children to collaborate and organise all the information necessary for teaching and learning”.

- eKool is an easily accessible web-based school management tool bringing together students and their families, schools and supervisory bodies.
- Stuudium is a suite of online apps for schools that connects teachers, parents and students. Study materials, information about academic progress and simple messaging are accessible in one online environment.
- State-provided E-schoolbag – the portal for digital learning materials – helps to find the educational materials located in different digital tools. The search engine contains materials for basic, general and vocational education.
- Privately owned OPIQ provides digital textbooks for all study levels and all subjects.
- Many schools in Estonia use the e-learning environment Moodle for lessons and information exchange. The Education and Youth Board of Estonia offers Moodle free of charge to general and vocational schools in Estonia.

It is not clear how, and by whom, many of these applications were developed and funded and whether schools’ access to them is free. However, Education Nation website says that the tools are typically co-created between schools, universities, and companies. The website also quotes Kristel Rillo, head of Digital Education at the Ministry of Education and Research: “having a well-established start-up ecosystem for educational companies in place for some years now the schools are supported to great extent with the e-services from the private sector.”

Curriculum and business administration choices

The Estonian national curriculum pays emphasis to the development of digital competences. It is one of the eight key competences that the schools in Estonia focus on. The assessment criteria included in the learner model describe what the learner needs to know by the end of each school level. In 2012 Estonia launched the ProgeTiger programme, which aims to improve the technological literacy of teachers and students. A variety of courses and training have been undertaken to this end, including programming, robotics and computer hobby groups, which have proved to be very popular. More and more kindergartens and schools are involved in the programme (Education Nation website).

Staff training

Digital learning has been a focus for teachers’ professional development in recent years. In TALIS 2018, the share of teachers who reported that information and communications technology (ICT) skills for teaching were included in their professional development activities, at 74.1%, was among the highest in the OECD (the OECD average was 60.4%). The professional standards for teachers, which form the basis of initial teacher education and continuing professional development, have recently been updated (2020) with an increased focus on digital pedagogy and inclusive education (OECD, 2020). To make it easier for teachers, Estonia has created digital competence models based on the European Commission’s educator’s digital competence framework DigCompEDU (Education Nation website).

Technical support

We could find no information in the literature about technical support from support staff. However, the Education Nation website describes the role of school-based educational technologists — experienced teachers and technology integration specialists who support teachers in schools. Their focus is on how digital resources can best be used to enhance the curriculum. “In [the]Estonian education system, an educational technologist is like an interpreter between teachers and the field of technology. They are experienced teachers who have completed a master’s degree to become technology integration specialists and have been working at Estonian schools since 2005. With the COVID-19 crisis, their role became even more important.” (Education Nation website)

Cyber security

In the initial decision making processes, academics played a vital role as part of the first formal advisory body on ICT, the Informatics Council, established in 1990. The focus on cybersecurity is a prominent feature of the x-road and this can be traced back to the Informatics Council, established in 1990 as many of its members had a connection with the Estonian Academy of Sciences' Institute of Cybernetics. From this institute, Cybernetica AS, one of the companies that delivers many of the public digital solutions, including x-road, was founded (Kattel and Mergel, 2018).

How (and by how much) infrastructure is funded, and how this investment is supported and delivered

Infrastructure in education has been a part of a much wider movement towards a digital public realm over the last 30 years with infrastructure typically being developed in small-scale public-private collaborative projects guided by design principles to ensure interoperability. That Estonia is a small country with almost one third of its 1.3 million inhabitants living in Tallinn has supported a clustering of population facilitated agile networks that were able to gain quick and lasting political support, and which required low initial infrastructure investment (Kattel and Mergel, 2018).

In 2009, the Ministry of Economic Affairs and Communications and the Estonian Association of Information Technology and Telecommunications (ITL) founded the Estonian Broadband Development Foundation (ELASA). The purpose of the Foundation is to give all residential houses, businesses and authorities a chance to connect to the next-generation broadband network with a transmission speed up to 100 Mbps. The roll-out of the high-speed middle-mile networks to sparsely populated areas, which were unlikely to be covered by market-driven deployment, involves laying over 6000 km of fibre-optic cables and the construction of network access points. These investments are intended to stimulate complementary deployments of last-mile connections by commercial telecom operators.

Estonia updated the targets and measures for broadband as part of its Digital Agenda 2020 in early 2014. The strategy envisages full coverage with connections of at least 30 Mbps by 2020 and aims to promote take-up of ultra-fast subscriptions with at least 100 Mbps with the objective that these account for 60% or more of all internet subscriptions by the same year. With its 5G roadmap, Estonia would like to achieve 5G connectivity in major cities by 2023 and along transport corridors by 2025. Estonia is in the process of putting together the new broadband plan for 2021-2030.

In total 208 million euros (174 million GBP) from the EU Recovery and Resilience Plan is devoted to digital objectives. The 24.3 million euros (20 million GBP) support for deploying VHCNs in rural areas is expected to ensure broader access to online services in 8,000 sites (European Commission, Broadband in Estonia, website accessed 23/02/2022).

Evidence of the cost effectiveness of different models

The Estonian Government claims that its egovernment infrastructure has led to annual savings of about 2% of GDP and more than 800 years in working time for the public and private sectors (Kattel and Mergel, 2018). The evidence for this assertion is not available in the Anglophone literature. Other than this, we have not found any cost effectiveness evaluations.

A mid-term evaluation of the Lifelong Learning Strategy, carried out by the Praxis think tank and the Estonia Centre for Applied Research (Centar), was published in 2019. The evaluation found significant progress in making digital learning resources more widely available, and in assessing the digital competencies of students and teachers, but identified a need to improve teachers' digital skills. A key recommendation was that strategic and operational planning needed to be better integrated in the next phase of the lifelong learning strategy (OECD, 2020). These recommendations appear to have been taken forward in the aims of the new learning strategy.

Finland

Summary and gaps

Finland has an extremely decentralised education system in which funding and decisions are highly delegated. While the state sets the national curricula and education strategies, these provide relatively loose frameworks in which local authorities and education providers can develop their own approaches. In addition, teachers have considerable pedagogical autonomy.

The Finnish Government has prioritised digital competencies in teachers, innovative use of technology to support learning and developing digital skills in pupils across curriculum subjects. This has been supported by a reform of curricula, new emphases in initial teacher education and ongoing professional development, and the funding of tutor teachers to support their colleagues to make the most of the opportunities of the use of digital technology in their teaching.

The decentralised approach, in which technology decisions are largely made and funded at a local level, means that there is little evidence in the Anglophone literature concerning connectivity and infrastructure; nor is there evidence of the central funding or mandating of any particular tools, systems or software. There is some evidence that the use of technology can be highly varied at the level of individual teachers. The comparative lack of levers available to the government means that change must be affected through collaborative approaches to policy development that engages stakeholders at all levels, along with discretionary funding related to particular initiatives.

Overview of school system

In Finland, compulsory schooling begins at the age of 7 and lasts for 9 years and is known as basic education. Upper secondary education is provided by general and vocational upper secondary institutions. The typical age of participation in upper secondary studies is from 16 to 19 years although, in vocational institutions particularly, a substantial proportion of students are older (Eurydice website (ud).

Some basic education schools in Finland cover the first six years of compulsory education (grades 1 to 6) and others cover the last three years (grades 7 to 9). An increasing number of schools cover all nine class levels, forming a general comprehensive school. In the first six years, teachers are generalists covering all subjects. In grades 7 to 9, teachers are specialists in one or two subjects (Kaarakainen and Saikkonen, 2021).

The system is highly decentralised and most education-related decisions are taken at municipal or institutional level, with strong stakeholder participation to be responsive to local needs. Decisions are steered from the centre by strategies, programmes and the national core curriculum. To further support coherence, the governance of all educational sectors and levels is integrated under the authority of the Ministry of Education and Culture (OKM) (OECD, 2020).

Local administration is the responsibility of local authorities, most commonly municipalities or joint municipal authorities. These make the decisions on distribution of funding, local curricula and recruitment of personnel. The municipalities have the power to delegate decision making power to schools and teachers have pedagogical autonomy in implementing the national curriculum, including teaching methods and the choice of textbooks and other learning resources. (Eurydice 2021d).

Funding

In Finland education is free at all levels from pre-primary to higher education. Adult education is the only form of education that may have fees in some cases. In preprimary and basic education, the textbooks, daily meal and transportation for students living further away from the school are free for the parents. At upper secondary level and in higher education the students themselves or their parents purchase their own books (MINEDU, 2018; Eurydice, 2021e).

While education spending fell in 2017 as a percentage of GDP (5.7% in 2017, compared with 6.1% in 2016), it remained well above the EU average of 4.6 percent and the proportion of private spend on education is the lowest in the EU (EC, 2019). Finland also spends more on education as a share of national wealth than on average across the OECD (5.5% in 2019, suggesting a continuing reduction in funding as a percentage of GDP, compared to 5.0%), and a high proportion of these funds at every education level are publicly sourced (OECD, 2020).

Most institutions providing basic and upper secondary level education are maintained by local authorities or joint municipal consortia. Responsibility for educational funding is divided between the State and the local authorities. Most private institutions do not differ from those that are publicly maintained. They follow the national core curricula and qualification requirements. They also receive public funding.

Pre-primary and basic education are part of the municipal basic services that receive a statutory transfer of funds from the government to the municipalities. The statutory government transfer is based on the number of 6 to15-year-olds living in the municipality and the special conditions of the municipality. The statutory government transfer for municipal basic services is approximately 25% of the calculatory costs.

The funding for general upper secondary education and vocational education and training is based on the number of students reported by the school as well as on the unit prices set by the Ministry of Education and Culture. The cost of basic education makes up the biggest share of expenditure at nearly 40%, not surprisingly as this is compulsory for all children (MINEDU, 2018; Eurydice 2021e).

Brief description of digital strategy

Saari and Säntti (2018) note that Finnish education policies have placed great emphasis on the use of digital technology in the education system at all levels. However, there is very little detail available in Anglophone primary sources. The same authors further note that the Minister of Education and Culture of the government formed in 2015 has frequently referred to the 'digital leap' to be taken in Finnish comprehensive schools, meaning that schools should quickly modernise their ICT infrastructures with, for example, state-of-the-art tablets and smartboards.

However, the challenge for Finnish policy makers is the decentralised nature of the system which means that government needs to persuade those at all levels in that system to implement their aspirations (Saari and Säntti, 2018; Kaarakainen and Saikkonen, 2021).

The Finnish Government's strategic programme in 2015 (English version unavailable) expected improved digital learning environments and new pedagogical approaches to promote future skills, increase lifelong learning, reduce drop-out rates, and increase opportunities of renewal in Finnish society (Kaarakainen and Saikkonen, 2021).

The updated Finnish national core curriculum for basic education (FNBE, 2016) describes seven inter-linked competences that are integral to civic skills, one of which is ICT competence. However, it is the responsibility of education providers to develop their own curricula within this framework (MINEDU, 2018).

A new strategic Programme was published by the government in December 2019 (Eurydice 2021c) but it is not clear from the Anglophone literature whether this contains any specific aims relating to the use of digital technology.

Priorities and timescales

There have been six official national-level digital education or Information and Communication Technology (ICT) strategies and hundreds of development projects during the last 35 years in Finland. Since 2015, these strategies have been integrated or embedded in other strategies, such as government programs or curriculum documents (Lavonen and Salmela-Aro, 2022).

Strategic Programme 2015

According to the government, the increased use of digital technology in education envisaged in the strategic programme of 2015 was intended to lead to collaborative learning environments and raise motivation among pupils. This, in turn, would develop the skills pupils will need for the future and enhance the nation's competitiveness in the global economy as these pupils move into the workplace (Saari and Säntti, 2018; Kaarakainen and Saikkonen, 2021).

In June 2015, Prime Minister Juha Sipilä published five key projects aimed at developing knowledge and education. The first of these concerned learning environments and digital materials in comprehensive schools, and one of its key development areas is the pre- and in-service teacher training. The key project (New Learning Environments and Digitalisation) was launched around the time of the implementation of the new national core curriculum for basic education, which began in autumn 2016. The comprehensive school action plan, which was created to support the implementation of the project, focused on three areas: new pedagogies, new learning environments and digital learning. The action plan determines three goals for comprehensive schools: learner-centred education, competent teachers and a collaborative school culture. The project was intended to make full use of teachers' skills and experiences while giving them extensive pedagogic latitude. Local solutions, creativity and experimentation would be encouraged (EDUFI, 2018; OECD, 2020; Vahtivuori-Hänninen [ud]). Aspects of the project included:

- The reform of pre- and in-service teacher education through the introduction of digital materials and new learning environments which will be facilitated through digital-pedagogic training. Every Finnish teacher will be offered access to online learning starting from their own level.
- Experimental schemes and workshops on pedagogy, digital learning and new learning environments will be instituted.
- The National Board of Education will establish a 'Centre for Innovations' to coordinate the experiments and to ensure the efficient dissemination of best practices.
- The introduction of tutor-teachers, a teacher supporting other teachers to utilise digital material and in the educational use of ICT. Existing teachers in the school receive additional training and development to take on the role. Actions may include organising training on digital pedagogy, conducting competence surveys, providing technical guidance or networking with peers. The initial plan committed to having 2,500 tutor-teachers in schools.

As part of this project, a Comprehensive School Forum (2016), comprised of a broad group of experts and stakeholders, developed a national vision for the future of Finnish education: “Finnish Basic Education: Excellence through Equity for All” (OECD, 2020).

New core curriculum

The common compulsory subjects are stated in the Basic Education Act. The national core curriculum defines the objectives and core content of each subject. In addition, the core curriculum defines the objectives for the learning environment as well as principles for guidance, support, differentiation and assessment. Education providers, municipalities and private education providers draw up local curricula and annual plans on the basis of the national core curriculum. The local curricula complement and amplify the objectives, core contents and other aspects taking into account the needs of the pupils, local circumstances and results from self-evaluation and development work. All local curricula must, however, define the values, underlying principles, as well as general educational and teaching objectives. (FNBE, 2016; MINEDU, 2018).

New national curricula are developed approximately every ten years. The construction of the current national curriculum for basic education was initiated in 2012, published in 2014 and became effective in 2016. The core curriculum describes seven transversal competence areas – that is knowledge, skills and values that cut across all subjects and all spheres of life. These are:

1. thinking and learning-to-learn
2. cultural competence, interaction and expression
3. taking care of oneself, managing daily life
4. multiliteracy
5. ICT competence
6. working life competence and entrepreneurship
7. participation, involvement and building a sustainable future (FNBE, 2016; MINEDU, 2018; OECD 2020)

The ICT competence emphasises the impact of the use of digital technology on learning, seeing opportunities for new pedagogies that increase the individualisation of the curriculum and develop collaborative skills in pupils. Information technology skills are thus seen as transversal skills, being integrated and applied in all school subjects, rather than as a separate school subject. In practice, the aim is to develop an understanding of the concepts of digital technology and skills in its use as a tool in information management, creative work, social communication, and networking. (Saari and Säntti, 2018; FNBE, 2016).

Strategic Programme 2019

The programme of the current government was submitted to Parliament on 10 December 2019 and its aim is to build a socially, economically and ecologically sustainable Finland by 2030. Within the programme are four education policy objectives:

- The level of education and competence among the population will rise at all levels of education, differences in learning outcomes will decrease, and educational equality will increase.
- Children and young people will feel well
- Education and training will enhance gender equality and non-discrimination in society
- Finland will be an internationally attractive place to study, conduct research and invest (Eurydice, 2021c).

We could not find a more detailed description of the programme to determine whether any specific aims relating to the use of digital technology sit within these overarching objectives. However, Finland's submission to Eurydice (2021d) notes that the Ministry of Education and Culture follows the objectives for social impact based on the government programme and those current objectives include:

- The potential of digital technology and new pedagogies have been utilised in learning and supporting the well-being and participation of children and young people. Learning environments have been modernised.
- The utilisation of digital technology, AIand robotics has made progress.

Is there funding attached to strategies/initiatives and how is this devolved?

Saari, A., & Säntti (2018) observed that, though the then government (formed in 2015) was reducing school funding, it would fund the development of 'new learning environments' that mostly consist of measures relating to the use of digital technology. Moreover, government funding would be allocated to teacher education and in-service training to encourage innovative uses of ICT in teaching. For most teachers, participation in continuing education is a requirement, and government typically funds continuing training programmes in areas important for implementing education policy and reforms (MINEDU 2018).

EDUFI (2018) provides an overall figure of 90 million euros (75 GBP approx.) between 2016 and 2019 to support the comprehensive action plan from central government. Vahtivuori-Hänninen, a project manager at the Ministry of Education and Culture, in an undated presentation on the New Learning Environments and Digitalisation project breaks this down into 50 million euros (41.5 million GBP) for funding teacher education and in-service training and 40 million (33.5 million GBP) for Experiments with Digital Learning. Within this, 23 million euros (19 million GBP) was provided by the government to train and support the network of tutor-teachers (OECD, 2020; EDUFI, 2018). In addition, education providers estimated that they contributed 2.5 million euros (2 million GBP) from their own funds to the programme. In 2017-2018 around 10 million euros (8.5 million GBP) were allocated to municipalities to hire tutor-teachers to support the use of digital tools (EU 2019), which is presumably part of the figure cited by OECD (2020). However, this funding linked to the Strategic Programme and accompanying plans and projects seems to reflect a more long-standing tradition: over the past 20 years, the Finnish National Agency for Education has annually allocated about 15 million euros (12.5 million GBP) for supporting the development of digital learning environments and for supporting teachers' professional learning of digi-pedagogy through training and development projects (Lavonen and Salmela-Aro, 2022).

Does the strategy provide a rationale for the level at which decision making to support the digital strategy and associated funding is delegated? (NB: this should also include relevant information on school/local autonomy in the country and the levers available to support strategy implementation)

Finland has a decentralised education system and local authorities and institutions have significant autonomy in determining educational provision. Most education-related decisions are taken at municipal or institutional level, with strong stakeholder participation within a relatively loose strategic framework set by central government (OECD, 2020; MINEDU, 2018; Saari and Säntti, 2018).

Stakeholder engagement is a headline characteristic of Finnish education. Key stakeholders include the Association of Finnish Local and Regional Authorities (Kuntaliitto), representing municipalities and regions, the Confederation of Finnish Industries and the Confederation of Unions for Professional and Managerial Staff (Akava), which facilitate labour market relevance, and various student and parent associations. Several organisations exist to represent the interest of teachers and other education professionals, including the Trade Union of Education (OAJ), the Central Organisation of Finnish Trade Unions and the Finnish Confederation of Professionals (OECD, 2020).

Central government does have some levers available to it, including setting the national curriculum and developing national strategies; although implementation of these is devolved in a way that allows for local interpretation. All educational decisions related to lower secondary schools were reported as being made across multiple levels in 2017; no other OECD country reported more than half of such decisions being shared across levels. In consequence, Finland has a well-established approach of preparing national-level strategies and curricula in collaborative, cyclical processes in order to develop a sense of shared authority and to maximise coherence in local adoption. Therefore, although central administration plays an important steering role, schooling decisions are mostly the responsibility of local education authorities (generally municipalities) and schools (OECD, 2020).

This decentralisation can be seen in the national core curriculum for basic education which is determined by the Finnish National Agency for Education. It contains the objectives and core contents of different subjects, as well as the principles of pupil assessment, special needs education, pupil welfare and educational guidance. The principles of a good learning environment, working approaches as well as the concept of learning are also addressed in the core curriculum. Education providers then draw up their own curricula within the framework of the national core curriculum, allowing for local or regional specificities. All local curricula must, however, define the values, underlying principles, as well as general educational and teaching objectives (OECD, 2020).

The state also funds both initial teacher training and some continuing education for teachers (annual participation in professional development is a contractual requirement for most teachers), usually in areas related to implementing national priorities (MINEDU, 2018). The 2015 Strategy aimed to reform pre- and in-service teacher education through the introduction of digital materials and new learning environments, facilitated by digital-pedagogic training. However, Vahtivuori-Hänninen (ud) identifies challenges in the lack of a national, systematic approaches to teacher education and regional differences in levels of participation.

There are no school inspections in Finland to determine compliance with national approaches (although schools carry out self-evaluations); instead, the state relies on persuasion, collaborative processes in the development of strategies, plans and curricula, and trust in schools and teachers (Eurydice 2021d; MINEDU, 2018; Saari and Säntti, 2018). This 'government at a distance' approach poses a particular challenge when attempting to increase the use of digital technology in education: "according to our analysis, the chosen strategy is to convince local administrators, principals and teachers of the necessity of a decisive leap and to urge them to take measures to realize it" (Saari and Säntti, 2018). As part of this strategy, the rhetoric of the 'digital leap' was adopted by policy documents, and this helped drive a rapid modernisation of information technology infrastructure and related teaching practices in schools (Kaarakainen and Saikkonen, 2021).

What evidence is there of approaches/initiatives instead of, or in addition to, a digital strategy?

Early in the pandemic, the Finnish National Agency for Education (EDUFI) collated resources to support online education, and developed an online information hub to guide teachers to adapt normal good practice. The Device for All campaign was expanded, which started in 2015 and encouraged private sector companies to donate laptops to students. EDUFI and the Association of Finnish Municipalities identified recipients for laptops (OECD, 2020).

Also inspired by the demands of distance learning in the pandemic, a group of Finnish education technology providers launched the website Koulu.me; an open innovation project that offers learning applications for pre-school to secondary education students in a wide range of subjects including maths, science, language learning and design (Good News from Finland website). Education technology companies provided e-learning materials at no cost to teachers, for an estimated cost of more than 10 million euros (8.5 million GBP), which equates to 15% of schools' annual total budget for learning materials (EU, 2021; Lavonen and Salmela-Aro, 2022).

Which bodies take decisions about spending in the delivery chain from government to individual schools and colleges?

Most institutions providing basic and upper secondary level education are maintained by local authorities or joint municipal consortia. Responsibility for educational funding is divided between the State and the local authorities. Most private institutions do not differ from those that are publicly maintained. They follow the national core curricula and qualification requirements. They also receive public funding (MINEDU, 2018; Eurydice, 2021d).

Overview of bodies taking decisions about technology choices

At national level, the strategic government programme outlines key goals and outcomes across a four-year period, including in relation to education. Parliament decides on educational legislation and the Ministry of Education and Culture (OKM) has responsibility for preparing and implementing education policy across all sectors and levels, from early years provision to adult learning. Other bodies that help shape education policy include:

- The Finnish National Agency for Education (EDUFI) is responsible for implementing policy from ECEC to upper secondary education, including VET. It works with the ministry to develop educational objectives, content and methods for early childhood, pre-primary, basic, upper secondary and adult education. EDUFI develops core curricula and qualifications requirements in VET, monitors expenditure, supports and develops teachers, and promotes internationalisation.

- The Finnish Education Evaluation Centre (FINEEC) conducts external evaluations of institutions and providers across the system and monitors learning outcomes for basic and upper secondary education.
- The six Regional State Administrative Agencies (AVIs) oversee regional equality in key public services, including universal access to quality education. They work in close collaboration with local authorities in an executive, steering and supervisory role. They are particularly important for the early years sector.
- The 15 regional Centres for Economic Development, Transport and the Environment plan, monitor and develop adult learning including enhancing staff competencies and improving services (OECD, 2020; MINEDU, 2018).

Municipalities or joint municipal authorities are responsible for providing early years care and education and basic education, often through a single administrative branch, to support coherence and facilitate transition. Municipalities allocate funds and recruit staff and, in collaboration with schools, develop detailed local curricula. Nevertheless, municipalities can and do delegate much of their decision making power to schools, particularly in urban districts (OECD, 2020; MINEDU, 2018).

The schools have the right to provide educational services according to their own administrative arrangements and visions, as long as the basic functions, determined by law, are carried out. In many cases, for example, budget management, acquisitions and recruitment are the responsibility of the schools. Typically, the principals recruit the staff of their schools. Education providers are responsible for practical teaching arrangements as well as the effectiveness and quality of their education (OECD, 2020; MINEDU, 2018).

Teachers have pedagogical autonomy and contribute to the design of local curricula, physical and digital learning environments and are responsible for the assessment of students' learning outcomes. They can decide themselves the methods of teaching as well as the choice of textbooks and materials (MINEDU, 2018; Lavonen and Salmela-Aro, 2022). Finnish teachers are trained to Master's level and encouraged to use theoretical knowledge and apply the curriculum at their own discretion in their day-to-day work (Saari and Säntti, 2018).

The outcome, then, is that the availability of technology in the school is, predominantly, the decision of the education provider (for the most part, the local authority). The use of technology in the classroom is at the discretion of the teacher (within the framework of the national curriculum and its interpretation at local level). An EC report (2019) found considerable improvements in teachers' digital competencies but ongoing disparities in the integration of digital tools in the classroom. Kaarakainen and Saikkonen (2021), in a study exploring the use of technology in Finnish schools, drew similar conclusions, stating that “the variation in teachers' technology usage in teaching occurs mainly at the individual level, and only a small proportion of the differences is explained by differences between schools.”

Specific decision areas (centralised or devolved) and links to strategies and funding

Broadband connectivity

While we have no information directly related to broadband connectivity in schools, Finland ranks 13th in connectivity amongst the EU’s 27 member states with 57% overall fixed broadband take-up. This is partly due to the high usage of mobile internet in Finland, with 4G networks close to saturation in certain areas and a lead in 5G readiness with commercial deployments under way. A significant urban-rural divide exists, as does a gap characterised by low population density and vast areas with comparatively low economic incentive to roll out connectivity networks. Finland’s national broadband plan, the digital infrastructure strategy, is being implemented. Finland is currently focusing on delivering at least the gigabit connectivity objectives. By 2025, all Finnish households should have access to a connection of at least 100 Mbps and it should be possible to increase connection speed to 1 Gbps (EU, 2021). This will also, presumably, benefit organisations too, including schools.

Digital infrastructure (including Wi-Fi, switching and cabling, servers and cloud storage and internal networking in school/college buildings)

We assume that this would be the responsibility of municipalities or, potentially, delegated to schools. We could find no specific information on this. There is the 2018 – 2022 digital Finland framework, supported with central government funding but information is not available in the Anglophone literature to determine if and how this might impact on schools.

Data (interoperability, security)

No information found.

Back-office systems (the software that supports the technology)

No information found.

Accessibility (for example, audio visual)

No information found.

Hardware (for example, laptops, desktops, tablets, peripherals)

No information found.

Software (for example, Management information systems, HR, finance, safeguarding, monitoring and filtering)

No information found.

Curriculum and business administration choices

The new national curriculum implemented from 2016, requires schools to integrate and apply ICT and digital skills in all school subjects without teaching ICT as a separate school subject. Offers of digital workshops, support from tutor teachers and teachers' participation in continuing education are intended to support increased technology usage in the classroom. However, the Finnish Reading Centre website notes that the use of digital learning materials at schools still remains at quite a low level although new digital materials are constantly being created. Textbooks, notebooks and exercise books continue to play a key role in everyday school life.

As a response to the pandemic, the Finnish National Agency for Education (EDUFI) collated resources to support online education and developed an online information hub to guide teachers to adapt normal good practice.

In addition, there is the Koulu.me website developed by education technology providers, free for schools to use.

Staff training

Both initial teacher training and continuing education have a focus on the digital competences of teachers and digi-pedagogy.

Technical support

According to EDUFI (2018), tutor teacher activities are one of the most significant practical measures in reaching Finland's goal of having the most competent teachers in the world. The activities are supported with 23 million euros (19 million GBP)in 2016–2018. The objective is to have tutor teachers in all 2,500 comprehensive schools in Finland to embrace new pedagogical approaches and promote the use of digital technology in teaching. The tutor teacher activities have been particularly supported with discretionary government transfers which education providers have been able to apply for from the Finnish National Agency for Education. The first discretionary government transfers were made available for application in autumn 2016. They were aimed towards supporting the training and development of the professional skills of tutor teachers as well as implementing tutor teaching and peer support in practice. The second application took place in autumn 2017.

We have no information on the employment or training of technology support staff, which would be the decision of either the municipality or delegated to the education provider.

Cyber security

Again, no school-specific information is available but In June 2020, to support the implementation of the cyber security strategy (2019), the government published a resolution on digital security in the public sector that sets out the development principles and key services to be considered to increase resilience in cybersecurity. The 2020-2023 action plan for digital security in the public administration describes how the resolution will be put in practice (EC, 2021).

How (and by how much) infrastructure is funded, and how this investment is supported and delivered

While outside the education strategies, Finland's government is also investing in digital infrastructure more broadly. Finland ranks 13th in connectivity amongst the EU's 27 member states with 57% overall fixed broadband take-up. This is partly due to the high usage of mobile internet in Finland, with 4G networks close to saturation in certain areas and a lead in 5G readiness with commercial deployments under way. A significant urban-rural divide exists, as does a gap characterised by low population density and vast areas with comparatively low economic incentive to roll out connectivity networks. Finland's national broadband plan, the digital infrastructure strategy, is being implemented. Finland is currently focusing on delivering at least the gigabit connectivity objectives. By 2025, all Finnish households should have access to a connection of at least 100 Mbps and it should be possible to increase connection speed to 1 Gbps (EU, 2021).

In June 2020, to support the implementation of the cyber security strategy (2019), the government published a resolution on digital security in the public sector that sets out the development principles and key services to be considered to increase resilience in cybersecurity. The 2020-2023 action plan for digital security in the public administration describes how the resolution will be put in practice (Digital Economy and Society Index (DESI) 2021 Finland).

The government has reserved 5 million euros (4 million GBP) for 2021 to implement its national broadband plan (by 2025, all Finnish households should have access to a connection of at least 100 Mbps). In addition, for very high-capacity connections in rural areas, resources from the European Agricultural Fund for rural development will also be available for 2021-2027. Decisions regarding the total amount of funds have not been at the time of writing. In addition, the multi-annual 2018-2022 digital Finland framework is being implemented for the digital transformation of local governments, with funding of 400 million euros (332 million GBP) over the whole period. Cybersecurity has also received funds in relation to broader e-government, for instance the 100 million euros (83 million GBP) project on the use of digital technology, experimentation and deregulation strategy for public sector ICT.

In Finland’s Recovery and Resilience Plan, the contribution to digital objectives accounts for 574.3 million euros (482 million GBP). The focus of the plan is on public digital services, digital skills and digital transition of economy. Investments include data-driven innovation (EUR 37 million, 31 million GBP), cybersecurity (EUR 20 million, 16.8 million GBP), connectivity in the areas where the market mechanism cannot deliver (EUR 50 million), digital skills at various stages of education and life, and related digital public services (over EUR 50 million, 42 million GBP), deployment of advanced technologies and digital R&D&I (EUR 43 million, 36 million GBP), and the digitalisation of businesses, including SMEs, innovation infrastructures, and grants for businesses development (EUR 40 million, 33.5 million GBP) (EC, 2021).

Evidence of the cost effectiveness of different models

Vahtivuori-Hänninen, a project manager in the Ministry of Education and Culture, in an undated presentation on New Learning Environments and Digitalisation, identifies as a key challenge, a slow transition of research findings, new learning environments and innovative pedagogical ideas into teaching practices. Recent national research, quoted by Kaarakainen and Saikkonen (2021), confirms that, although the use of digital tools is gradually increasing in teaching, there has been no significant transition towards digitality in learning situations in Finnish basic education. Through analysis of data originally collected in Finland during 2017–2019 for a project called “Comprehensive Schools in the Digital Age” funded by the Prime Minister's Office and the Ministry of Education and Culture from two representative samples of Finnish municipalities, Kaarakainen and Saikkonen (2021) concluded that initiatives intended to increase the use of digital technology in education have impacted on the work of some teachers much more than others. This variation in teachers' technology usage in teaching occurs mainly at the individual level, and only a small proportion of the differences is explained by differences between schools. An EC report (2019), similarly found considerable improvements in teachers’ digital competencies but ongoing disparities in the integration of digital tools in the classroom.

EDUFI (2018) conducted a survey of tutor-teachers (2017) to assess the impact of the discretionary government transfers, which concluded that the project had a highly positive impact. A total of 2,289 tutor-teachers were operating across 90% of municipalities by 2018, over 80% of whom had been trained via the government’s discretionary transfers. Over half of the education providers had combined training carried out by their own organisation with a purchased service.

At the start of the application period for the discretionary government transfers, the following focus areas were set:

- the school’s capacity for long-term development
- innovation and experimenting skills
- competence in peer training, and mentoring and coaching skills
- interaction and networking skills
- pedagogical digital skills

91% of the respondents considered that they had achieved all of these focus areas very or fairly well. Ongoing challenges include demand for a more regional focus to the tutor network, guidance from OKM as to the competences tutor-teachers should work on and securing a long-term funding strategy.

France

Summary and gaps

In 2015 the French Government introduced a new digital strategy for schools (‘Schools Change with the Digital Age’), which involved a commitment by the government to invest in the region of one billion euros (0.85 billion GBP) in digital education. In August 2018, the strategy was renamed ‘digital technologies serving a school of trust’.

The Ministry of Education’s current priorities include targeting support towards the communities and regions with the biggest challenges in accessing digital technology; the protection and improved use of educational data; and simplifying administrative formalities for student and parents. The implementation of the national digital plan is managed by the national Directorate of Digital technologies for Education, regional ICT advisors and the directors of the départements’ education services.

Decisions about technology choices are informed by an annual national survey of primary and secondary schools, which provide indicators on equipment, infrastructure, human resources, digital services, safety, teacher training, and more. The indicators are used, among other things, by the local authorities, when they need information before equipping schools. While is unclear how much autonomy is devolved to schools in decision making concerning technology, it appears that lower secondary and upper secondary schools do have a degree of flexibility regarding the use of government grants and in how they achieve national objectives.

In 2019 the French Court of Auditors (Cour des Comptes), which is responsible for monitoring state spending, recommended that future investments should be better linked to teacher training, innovative pedagogies, new pilot projects and use of (AI) for education.

Overview of school system

Education is compulsory in France from three years old until 16. However, a law stipulating that that all young people must receive training until 18 years old was introduced in the academic year 2020/21. This measure aims to prevent adolescents being left in circumstances where they are not in education, training or employment. The compulsory training requirement is met when adolescents aged 16 to 18 are:

- In school or in a specific apprenticeship programme
- In a programme of support for social and professional integration
- In civic service or employment

Young people who provide a medical certificate attesting to difficulties linked to their state of health are exempt from this obligation (Eurydice (23 October 2020).

Types of schools

Compulsory education consists of:

- three years of pre-primary education in nursery schools (ages 3-5)
- five years of primary education at elementary school (ages 6-11)
- four years of lower secondary education at collège (ages 11-15)
- one year at an upper secondary education at lycée (ages 15-16), although upper secondary schools provide education up to the age of 18 (Eurydice, 2021a).

Upper secondary education, provides three educational paths:

- General path (lycée général) which leads towards further studies in higher education
- Technological path (lycée technologique) which mainly prepares pupils for higher technological studies
- Professional path (lycée professionnel) which trains students in a particular profession in fields such as hospitality & catering, mechanics, industrial design and sales. (Students taking the professional option can also extend their training with short-term higher education) (Eurydice, 2021a).

The private sector (which accounts for approximately 20% of pupils) is divided between schools that have signed a contract of association with the state and schools without a contract. In return for state funding, those that have signed a contract (approximately 80% of private schools) must provide the same education as public schools, recruit teachers who are employed under public law and undergo the same inspections as public schools (Eurydice, 2021c).

The general national curriculum framework in France is centralised. It is defined at central level and defined for study cycles (3 years for instance). Within the curriculum framework, teachers are relatively free to choose their own pedagogical approach (European Schoolnet, 2018).

Funding

Primary education and secondary education are provided free of charge in public schools. There are, however, costs for households, linked to catering and various activities (Eurydice, 2021c).

Over 90% of the funding for the school education system is funded by the state, the three levels of government below the national level (administrative regions, départements and communes), other public administrations (such as consular bodies, chambers of commerce and industry, and hospitals) and public and private companies (Eurydice, 2021c). The State is the leading funder of education (57.3%), ahead of the three levels of local government (23.3%) (as at 2019) (MENJS-DEPP, 2020).

A very large part of State expenditure is due to the remuneration of education staff (teachers, management staff, etc.) and, to a lesser extent, aid to families through the payment of grants. The three levels of government under the national level cover the cost of technical staff and almost all operating and investment costs. They also manage catering and accommodation, school transport, and the remuneration of non-teaching staff:

- The regions finance upper secondary schools (ISCED 3): general and technological lycées, vocational lycées and regional adapted education institutions (EREA). The regions are also involved in funding apprenticeship training
- The départements fund lower secondary schools (ISCED 2)
- Municipalities fund nursery and primary schools (ISCED 02 and ISCED 1) (Eurydice, 2021c).

Public and private companies, which in 2019 contributed 8.4% of domestic expenditure on education in 2019 (MENJS-DEPP, 2020), are particularly involved in financing apprenticeships (via the apprenticeship tax), both public and private, in the vocational stream of upper secondary education (Eurydice, 2021c).

Regarding the financing of private sector schools, in the case of those schools that have signed a contract of association with the state, the state covers the remuneration of teaching staff, the social security and tax charges payable by the employer and the costs of initial and in-service teacher training. The tuition fees of these schools are set by each school and therefore vary greatly. At the start of the 2018 school year in government-dependent private schools, the average parental contribution per year and per pupil varied between 389 euros (326 GBP) and 1,176 euros (987 GBP) depending on the level of education (from nursery to high school). The tuition fees of public schools that have not signed a contract of association with the state are higher because the schools do not receive state funding for teachers' salaries, maintenance of the premises, and operating costs (Eurydice, 2021c).

The départements and regions also contribute to the financing of secondary schools under contract (collèges and lycées respectively) (Eurydice, 2021c).

Brief description of digital strategy

France’s digital strategy for schools was entitled ‘schools change with the digital age’ between 2015-2018. This represented France’s biggest national digital plan for education ever and was announced by French President François Hollande on 7 May 2015. The aim was to mainstream digital technology in schools at all education levels at the start of the 2016 school year, but with priority given to the first secondary school classes (ISCED 2). To transform teaching and learning practices with digital technology, four pillars were identified at this stage: training for teachers, equipment, resources and innovation (Watkins 2017).

France’s digital strategy was renamed ‘digital technologies serving a school of trust’ as from 21 August 2018. The five current priorities are to:

- Put school data at the centre of the digital strategy
- Teach for the 21st century using digital technologies
- Support and strengthen teachers' professional development
- Develop students’ digital competences
- Create new links with other stakeholders and school partners (European Commission/EACEA/Eurydice, 2019)

Priorities and timescales

van der Vlies (2020: 36) lists the following core elements of France’s current digital strategy for schools:

- Protection and improved use of educational data
- General interest in development of AI (improved learning and assessment, relieving teachers of tedious tasks), Internet of Things (IoT), blockchain, free and open resources
- Digital resource bank
- National Center for Distance Education
- Support for digital skills
- Simplifying administrative formalities for student and parents
- Supporting partnerships between companies and schools

Is there funding attached to strategies/initiatives and how is this devolved?

Public funding for digital education development is estimated at one billion euros (0.85 billion GBP) (Watkins, 2017; OECD, June 2020), although it is not entirely clear whether this was for the period 2015-2018 (as indicated by Watkins 2017) or is ongoing.

Does the strategy provide a rationale for the level at which decision making to support the digital strategy and associated funding is delegated? (NB: this should also include relevant information on school/local autonomy in the country and the levers available to support strategy implementation)

The Ministry of Education and regional/local public authorities are working together and jointly mobilising financial resources in order to implement the national plan (Watkins, 2017).

At the ministry level, the Directorate of Digital technologies for Education (la Direction du Numérique pour l'Education" (DNE)) is responsible for matters related to ICT in schools (European Schoolnet, 2018). The mission of the DNE is to stimulate and support the digital transformation of the education system for the benefit of the educational community as well. It coordinates the actions of the Ministry of National Education in terms of information systems, development of digital services and digital innovation, development of digital culture and management of digital skills. In this capacity, it represents the ministry with the inter-ministerial structures responsible for digital and information and communication systems. It coordinates the digital component of the activity of school education operators, in conjunction with the general direction of school education, the general direction of human resources, the direction of financial affairs and defines the strategic orientations in this area (European Schoolnet, 2018).

Administrative responsibility for education at a regional level is undertaken through 18 administrative regions, each of which is headed by a Recteur who is a civil servant and an appointee of the Minister of Education. The regions contain 30 local education authorities (academies), each of which covers several départements (European Schoolnet, 2018). The "academies", which are regional structures of the Ministry of Education, are in charge of implementing national directives and policies. The regional education authority gives impetus to the development of ICT. It coordinates the different levels of teaching and establishes partnerships with local and regional authorities, companies, other administrations and organizations (European Schoolnet, 2018).

The ICT advisor (DAN: Délégué académique numérique) oversees the actions related to ICT in regional education authorities and coordinates the various networks of people and partners involved in ICT, notably the network of subject leaders and the network of persons dedicated to primary education concerned with ICT. The ICT advisor is appointed by the representatives of the Minister of Education (European Schoolnet, 2018).

At a département level the directors of the départements' education services are responsible for coordinating and implementing education policy, except in the Paris and overseas academies. They represent the regional heads (Recteurs) and participate in the overall definition of the academic strategy which implements the educational and pedagogical policy relating to primary and secondary education decided by the Minister in charge of Education. Under the authority of the rector, they implement the academic strategy organising educational action in schools, colleges, high schools and special education establishments in their department (European Schoolnet, 2018).

What evidence is there of approaches/initiatives instead of, or in addition to, a digital strategy?

In 2018, the government announced the following investment programme for 2018 and 2019, which is in addition to the national education budgetary appropriations:

- Innovative Digital Schools and Rurality Initiative: co-financing by the State of about 150 projects (concerning about 800 schools): approximately 4 million euros (13.38 GBP)
- Launch of a second wave of co-financing for municipalities of under 2,000 inhabitants: 20 million euros (6.91 million GBP)
- Launch of an innovative AI education partnership: 8 million euros (6.77 million GBP)
- Development of three new digital resource banks for schools (BRNE) for languages and cultures of Antiquity, modern languages and French: 3 million euros (2.54 million GBP)
- Simplification and personal-data protection: 2 million euros (1.69 million GBP)
- Development of scientific digital assessment for education: 1 million euros (0.85 million GBP)
- Massive Open Online Courses (MOOCs) and other digital solutions to encourage enrolment in higher education: 10 million euros (8.46 million GBP) (Ministry of National Education, 2018: 51)

The government also announced that new calls for projects, reflecting the continuation of digital-technology investments for schools, would be launched during the 2018-2019 school year (Ministry of National Education, 2018: 51).

Which bodies take decisions about spending in the delivery chain from government to individual schools and colleges?

As indicated above, the national Directorate of Digital technologies for Education, the regional ICT advisors and the directors of the départements' education services are the key bodies involved in decisions about spending.

The extent to which primary and secondary schools contribute to decisions about spending is not made clear in the Anglophone literature.

Eurydice (2021a) reports that lower secondary schools (collèges) and upper secondary schools (lycées) have room for manoeuvre in how they manage budgets granted by the State, as well as in the definition of what educational strategies to adopt in order to achieve national objectives.

Overview of bodies taking decisions about technology choices

- The national Directorate of Digital technologies for Education oversees the digital component of the activity of school education operators and the direction of financial affairs.
- At the regional level ICT advisors coordinate the different levels of teaching and establish partnerships with local and regional authorities, companies, other administrations and organisations.
- Directors of départements' education services participate in the overall definition of the strategy for implementing national policies and, under the authority of their regions' Recteur, implement the strategy by organizing educational action in schools, colleges, high schools and special education establishments in their department (European Schoolnet, 2018).

Decisions about technology choices are informed by an annual national survey on ICT known as ETIC (Enquête sur les Technologies de l'Information et de la Communication), which is conducted in primary and secondary schools. The survey aims to provide indicators on equipment, infrastructure, human resources, digital services, safety, teacher training, and more. The indicators are used as follows:

- To provide information about digital technologies in schools;
- To analyse progress in implementing digital technologies;
- To compare ICT policies at different levels (regional, etc.);
- By the local authorities, when they need information before equipping schools (European Schoolnet, 2018).

Specific decision areas (centralised or devolved) and links to strategies and funding

Broadband connectivity

The proportion of schools with high-speed internet connectivity at all education levels is lower than the EU average (European Commission, 2019a).

In TALIS 2018, more than two-fifths of primary school leaders in France reported that insufficient Internet access affects their school's ability to provide quality education. Another 57% said that digital equipment for teaching is insufficient or unsuitable. These obstacles are more prevalent in schools in disadvantaged areas designated as priority zones, with 70% reporting insufficient internet access and 76% reporting insufficient digital equipment, and for schools located in large cities, with 65% reporting insufficient internet access and 73% reporting insufficient digital equipment (OCED, June 2020).

Digital infrastructure (including Wi-Fi, switching and cabling, servers and cloud storage and internal networking in school/college buildings)

No information found.

Data (interoperability, security)

School data collection and links with new stakeholders outside the school underpin the digital strategy (Eurydice, 2019).

Back-office systems (the software that supports the technology)

The French National Office for Information on Education and Professions (ONISEP) is expanding its digital platform to help twelfth-graders, their parents and educational staff to better understand higher education courses. To help teachers in their mission of guiding students to the best educational path, ONISEP has launched new tools for secondary-school staff, including self-training modules, organised by grades and skills (Ministry of National Education, 2018: 49).

Accessibility (for example, audio visual)

The digital educational resources bank (BRNE) is available to students and their teachers from fourth to ninth grades in order to contribute to improving the full academic integration of students with disabilities as well as facilitating their parents’ monitoring of their education. Support is also provided for resources designed specifically to meet the needs of students with learning disabilities or autism, in particular through the Ministry’s Edu-Up system (Ministry of National Education, 2018: 50).

The law regulating/banning the use of mobile phones in primary and lower secondary school (introduced in September 2018) allows the use of digital tools by students with disabilities (Ministry of National Education, 2018: 74).

Hardware (for example, laptops, desktops, tablets, peripherals)

As part of the 2015 Digital Education Plan, France deployed a longitudinal assessment of educational digital activities – ELAINE – to measure the effects of the distribution of digital equipment on students' skills and on teaching practices and the attitude of teachers towards digital learning. The measurements started in 2018 and 2019 (van der Vlies, 2020: 9).

Software (for example, Management information systems, HR, finance, safeguarding, monitoring and filtering)

EduConnect is designed to simplify and accelerate the administrative procedures required of parents and give them, in real time, more extensive and complete information on the education of their children, while bringing parents and teachers into closer contact. It aims to address all the legal guardians of pupils in primary school, middle school and high school, and ultimately all pupils, to enable them to access online services related to education. The EduConnect account allows access to: the Ministry's Education Services portal to carry out online procedures (such as applications for scholarships and registration); school reports and school records; and a digital work space (ENT) (Ministry of National Education, 2018: 51; Schoolnet, 2018).

Curriculum and business administration choices

Since the introduction of the Digital Strategy Plan for schools in 2015, digital technology is now present in all school curricula from primary to upper secondary (OECD, June 2020).

France recently increased the presence of information and communications technology (ICT) in the curricula, especially regarding information quality and computer sciences. At upper secondary level, France created two new courses: digital and technological sciences (Sciences numériques et technologiques), compulsory in the first year, as of 2019/20; and digital and computer sciences (Numérique et sciences informatiques), an optional specialist subject within the general Baccalaureate. France also developed a Reference Framework of Digital Competences (Cadre de référence des compétences numériques), based on the European framework, covering primary, secondary and tertiary education with end-of-cycle assessments (OECD, June 2020; European Commission/EACEA/Eurydice, 2019; Ministry of National Education, 2018).

France is also seeking to harness the potential of AI for education. A partnership with the private sector will develop pedagogical resources based on AI to support teachers with differentiated and personalised learning of French and mathematics in grades 1-3 of primary education. A voice assistant to learn English in primary education will be tested in 2020 as part of the modern languages plan. A working group of AI researchers in the National Education Council will also support educational innovation. Four multidisciplinary Artificial Intelligence Institutes (Instituts Interdisciplinaires d'Intelligence Artificielle (3IA)) are developing research, training and innovation clusters in specific fields, involving the creation of 150 Chairs in AI (European Commission, 2020).

France has invested strongly in digital platforms for education and training in recent years (European Commission (2020). These include: Pix, the Homework Done programme; the D'COL platform; the School, Digital, Industry (ÉNI) project; and OpenENT.

PIX

Pix is a free online public service to assess, develop and certify digital competences for pupils, higher education (HE) students and workers. Since 2019, secondary students in France have had access to the Pix tools through their school's digital learning platform to regularly test their digital skills (through a series of exercises that adapt to the level of student proficiency) and to achieve certification, based on the EU's Digital Competence framework (DigComp) (European Commission, 2020; Ministry of National Education, 2018: 51; European Schoolnet, 2018).

Homework Done

Homework Done is an online tool created by the French National Center of Distance Education (CNED), which offers instant help on lower secondary-school skills, as well methodological support, allowing students to become more autonomous when doing their homework (Ministry of National Education, 2018: 51; European Commission, 2020).

The D'COL platform

The D'COL platform supports students in priority zones in mathematics in fourth to sixth grades and provides unlimited access to personalised assistance. Teachers in the first and second grades of primary school in disadvantaged zones have a platform to exchange pedagogical practices and other useful information. Inclusive School Cap assists teachers working with disabled students (Ministry of National Education, 2018: 51; European Commission, 2020).

The School, Digital, Industry (ÉNI) project

The School, Digital, Industry (ÉNI) project aims to create a platform of digital educational resources that promote industry. Developed in partnership with industry, it offers digital resources for professional and technological education to support career guidance and better preparation for the workplace. After a successful first experience in the fields of energy, construction and robotics, this Etincel platform will progressively cover all industrial sectors, offering students and teachers educational resources for vocational and technological education.

OpenENT

ENT stands for Espace Numérique de Travail in French, or virtual learning environment in English. Designed to benefit the entire educational community, OpenENT is used by 2 million pupils and students in France at more than 1,700 schools. “monLycée.net”, “Paris Classe Numérique” and “lyceeconnecte.fr” are all digital workspaces based on OpenENT. They operate as a social network dedicated to education that is 100% secure and under the control of the school. OpenENT enables a circle of trust between pupils, parents and teaching staff while contributing to the continuity of teaching.

Staff training

In order to enable teachers to adopt digital tools and use them to enhance teaching and learning, a major digital training plan has been deployed since 2016 with a mandatory three-day training course for all lower secondary teachers. Since 2018, the ministerial strategy has placed data (both protection and enhancement) at the heart of its strategy (OCED, June 2020).

The M@gistere platform offers around 400 free distance education courses to lower and higher school teachers and education staff. It is also a platform with communities and co working spaces. Teachers can have access to a blended approach of distance learning and onsite learning (Schoolnet, 2018).

New teachers entering the profession need digital certification, and a new master’s degree in digital education has been introduced to develop specialist ICT teachers (European Commission, 2020; OECD, June 2020).

Technical support

No information found.

Cyber security

No information found.

How (and by how much) infrastructure is funded, and how this investment is supported and delivered

The national broadband programme France Très Haut Débit sets out the targets of fast broadband access for all households by 2022 with 100% coverage with 30Mbps, and fibre access for all by 2025. The National Agency for Territorial Cohesion (l'Agence Nationale de la Cohésion des Territoires) is responsible for implementing France's broadband strategy (European Commission, Broadband in France, website accessed 23/02/2022).

French officials expect that the national strategy will require mobilisation of private and public investments of up to 20 billion euros (16.7 billion GBP). The Fund for the Digital Society (Fonds pour la société numerique) provides a combination of public loans and funding to support the roll-out of ultrafast broadband by the French Government. Infrastructure projects that are eligible include works on backhaul networks (FTTN), passive fibre optic networks (FTTH), customer access (FTTH), access for public institutions (education, health, public administration), support for Wi-Max and/or satellite receivers as well as feasibility studies for planned roll-out projects.

France assigned 3.3 billion euros (2.8 billion GBP) to the implementation of the plan Très Haut Débit. An additional 240 million euros (200 million GBP) were allocated to boost connectivity in rural areas as part of the France's Recovery and Resilience Plan.

Evidence of the cost effectiveness of different models

In 2019 the French Court of Auditors (Cour des comptes), which is in charge of monitoring state spending, recommended that future investments should be better linked to teacher training, innovative pedagogies, new pilot projects and use of AIfor education (European Commission, 2020).

Ireland

Summary and gaps

Irelands Digital Strategy for Schools 2015-2020 expired at the end of the 2020-2021 school year and a new strategy is currently in development. A consultation framework has been established and an open public call for written submissions from stakeholders on the development of the new Digital Strategy for Schools took place between 14 April 2021 and 18 June 2021. A key element of the new strategy is likely to be to address the digital divide that was exposed by the move to online learning during the COVID-19 pandemic. €200m (169.15 million GBP) has been allocated to fund the implementation of the policies developed under the new Digital Strategy for Schools up to 2017.

Alongside the development of a new Digital Strategy for Schools, the Department of Education recently announced two major ICT projects supporting primary and post-primary schools. The first of these involves €50 million (42.29m GBP) in grant funding which will be used to enable all primary and post-primary schools in the free education scheme to invest in digital infrastructure to support students who are most at risk of educational disadvantage through the digital divide. The other project involves €13.5m (11.42m GBP) to supplement delivery of high-speed broadband alongside delivery under Ireland's National Broadband Plan, and commercial provision via the Schools Broadband Programme, through which the Department of Education directly funds the provision of broadband connectivity to schools at an annual cost of around €13m (10.00m GBP).

Many aspects of the administration of the Irish education system are centralised in the Department of Education, and the Department deals directly with most schools. Funds for digital strategies and initiatives are devolved directly to schools in the form of grants. Schools have a considerable degree of autonomy in how they spend the grants, as the focus has largely been about supporting schools and teachers to develop digital learning plans for their schools and make informed choices about digitisation. However, the Department for Education does have levers at its disposal such as curriculum frameworks, teacher training and a national support service for schools on digital technologies that enable it to improve the knowledge and use of digitisation in schools.

Overview of school system

Compulsory schooling in Ireland is from the age of 6 to age 16 or until students have completed three years of post-primary education, whichever is the later.

The Irish primary education sector consists of 3,115 state-funded primary schools, 135 special schools and 27 private primary schools. State-funded primary schools are predominantly religious denominational schools, but they also include multidenominational schools and Irish medium schools (Gaelscoileanna). Special schools provide education up to completion of upper secondary education but are nonetheless treated as primary schools. Private primary schools, which do not receive any State funding, offer a similar type of education to state-funded primary schools, and cater for around 0.7% of overall primary enrolment. The State has no role in these, other than ensuring that children receive a "certain minimum education" required by the Constitution.

Post-primary schools fit into four categories: voluntary secondary schools, vocational schools and community colleges and community and comprehensive schools. Voluntary secondary schools are state-established, owned by a Trustee/Patron and managed by a Board of Management. Trustees/Patrons of voluntary secondary schools include bishops, religious orders, boards of governors, education trust companies and private individuals.

Some offer free or subsidised tuition and receive government funds, while others are fee-paying. In both cases, the Irish state covers salary costs for all of them. Traditionally, voluntary schools offer a purely academic education, but they have begun to provide practical and vocational subjects too. These are the most common and popular schools throughout Ireland.

Vocational schools and community colleges are also state-established but are run by Ireland’s Education and Training Boards (ETBs). They deliver the national curriculum with a focus on practical skills and vocational training.

A third of Ireland’s secondary facilities fall into this category. Community and comprehensive schools, offering both academic and vocational courses, are entirely financed by the state and are managed by local boards of management (Eurydice: National Education Systems: Ireland).

In May 2005, the Department of Education introduced the Delivering Equality of Opportunity in Schools (Deis) scheme which focuses on addressing the educational needs of children and young people from disadvantaged communities, from pre-school through second-level education (3 to 18 years). As of October 2021, the scheme offered additional financial and staffing supports for 884 Deis-designated schools with high levels of educational disadvantage. Funding for a major expansion of the programme was announced in the Irish Government’s Budget 2022 and it was indicated that several hundred more schools would be brought in to the Deis scheme (Donnelly, 14 October 2021).

Many aspects of the administration of the Irish education system are centralised in the Department of Education, under the direction of the Minister for Education. Apart from the 16 ETBs which are responsible for the for the 265 vocational schools and community colleges, there is no regional or local structure for schools in Irish educational administration.   Therefore, all primary schools (3262) and 470 of the 735 post primary schools deal directly with the Department of Education. The Public Service Management Act, 1997, puts a statutory obligation on the Department to pursue excellence and transparency in its dealing with the education partners (Eurydice: National Education Systems: Ireland; Eurydice, 2021a).

Funding

The State pays the bulk of the building and running costs of all State-funded primary schools. However, the State grant is supplemented by fundraising at local level and by voluntary contributions from parents. State aided primary schools may not charge fees.

There are 711 post-primary schools financially aided by the Department of Education and Skills. All vocational schools, comprehensive/community schools are funded directly or indirectly by the Department of Education. The majority of free-scheme (non-fee-paying) voluntary secondary schools receive capitation grants and some additional grants from the Department of Education. The fee-paying voluntary secondary schools do not receive capitation or other grants, however, the salaries of their teachers (within the recognised pupil-teacher ratio) are almost fully paid by the Department of Education. Under an arrangement dating back to the introduction of the Free Education scheme in 1967, the Boards of Management of voluntary secondary schools are required to pay a portion of the salaries of teachers they employ. This is known as the Teachers' Salary Grant and amounts to €562 (472 GBP) per teacher. This sum is deducted by the Department from the capitation grants due to voluntary secondary schools who do not charge fees. The Teachers' Salary Grant is repaid directly to the Department by voluntary secondary schools that charge fees, as they do not receive any capitation funding from the Department. (Eurydice: National Education Systems: Ireland; Eurydice (2021b)

Primary schools are required to spend their funds on the categories of expenditure for which they are earmarked i.e., capitation grants are for heating, cleaning and other expenses; ancillary services grants are for caretaking, secretarial and other supports etc. Teachers and special needs assistants are paid directly by the Department. Therefore, the extent to which schools could be deemed to have discretionary funding is limited. However, each school appoints its own staff (within the numbers approved by the Department) and is responsible for their assignment to duties across the school. The national curriculum is built on a set of learning outcomes for each two- yearly period, and schools have discretion as how to achieve these outcomes. The Rules for National Schools and various circulars from the Department of Education, determine the general framework for the operation of schools. Pay and conditions of educational staff are determined centrally by the Department.

Post-primary schools are required to spend their funds on the categories of expenditure as above for primary schools. All secondary level, schools other than vocational schools appoint their own staff, within the numbers approved by the department. In vocational schools, staff are appointed by the ETBs, and schools receive all their funding through the ETBs. All State funded schools are required to deliver the national curriculum but have discretion as to how this is achieved. Students sit national examinations run by the State Examinations Commission (SEC). Apart from a number of required subjects which all schools must deliver, schools have discretion as to subject offer.

Each school is managed by a school board of management with responsibility for the accounts. School accounts are also subject to public audit on a sample basis. In vocational schools, all funds are allocated by the department to regional ETBs. While the ETB must spend earmarked funding on the services for which it was intended, it has discretion as to how to distribute these funds across schools. ETB accounts are submitted to the Department for Education, and are examined fully by the department as well as being subject to public audit. All ETBs have their own governance structures set out in legislation (Eurydice, 2021b).

Brief description of digital strategy

Ireland's Digital Strategy for Schools (2015-2020) expired at the end of the 2020-2021 school year. The aim of this strategy was to "realise the potential of digital technologies to enhance teaching, learning and assessment so that Ireland's young people become engaged thinkers, active learners, knowledge constructors and global citizens to participate fully in society and the economy". The strategy provided a rationale and a government action plan for embedding digital technology in all classroom and school activity to make the use of digital technology a seamless part of the entire education experience. The Strategy was developed around four key themes:

Theme 1: Teaching, Learning and Assessment Using ICT

Theme 2: Teacher Professional Learning

Theme 3: Leadership, Research and Policy

Theme 4: ICT Infrastructure

The implementation of the strategy was supported by a Digital Learning Framework (DLF) and digital learning planning guidelines and CPD, resources and supports for teachers and school leaders (Department for Education and Skills, Ireland, 2015).

On 5th April 2021, Ireland's Minister for Education Norma Foley TD announced that a new Digital Strategy for Schools was to be developed (Department of Education, Ireland, 5 April 2021, last updated 6 April 2021).

In order to ensure a comprehensive review of the 2015- 2020 strategy and to inform the development of a new strategy, a New Digital Strategy for Schools Consultation Framework has been developed. This has been presented as "an integral part of the development of the new strategy and key to ensuring its successful implementation."

This consultation framework comprises five elements:

- An open public call for written submissions from stakeholders on the development of the new Digital Strategy for Schools. This took place between 14 April 2021 and 18 June 2021. Stakeholders were "encouraged to express their views in terms of the implementation of the current strategy, any challenges that arose and their suggestions for areas and priorities that the future strategy should address;
- An easily accessible digital questionnaire for all teachers, principals and students;
- Focus groups on specific themes with main stakeholders (for example education partners, industry, students, parents);
- Establishment of a core Consultative Group, which will include the management bodies, unions, parents' representative bodies and industry representatives. The Consultative Group will meet on a regular basis with other key stakeholders invited to attend depending on the themes to be discussed;
- Bilaterals with other Departments and Agencies, including Northern Ireland, the EU and the UK.

(Department of Education, Ireland, 14 April 2021, last updated on 12 August 2021).

The development of the new strategy is still underway and the outcomes of the different strands of the consultation process have not been published to date.

On 1 February 2022, the minister reported that the digital strategy is currently in the final phases of development (Dáil Éireann Debate, 1 February 2022).

Priorities and timescales

Although details of Ireland's new Digital Strategy for Schools have not yet been published, press releases issued by the Department of Education confirm that the strategy will be in line with the European Commission's 'The Digital Education Action Plan 2021 – 2027', which has a vision to provide "high quality, visible and inclusive digital education in Europe". Department of Education press releases and media reports also indicate that the new strategy will be aimed at embedding digital technology in the learning process where digital gaps became apparent during the COVID-19 pandemic, following a sudden move to online teaching. This exposed a digital divide that that has had a negative impact on learning for disadvantaged children. The Irish Government recognises that more funding is needed to support digital infrastructure, particularly for schools in disadvantaged communities (Department of Education, Ireland, 5 April 2021, last updated 6 April 2021; Donnelly, 5 April 2021).

Is there funding attached to strategies/initiatives and how is this devolved?

The Department of Education has earmarked 200 million euros (169.15 million GBP) to fund the implement of the policies developed under the new Digital Strategy for Schools up to 2027. This will be provided under Project 2040, the Irish Government's "long-term overarching strategy to make Ireland a better country for all of its people, through the National Development Plan".

The previous Digital Strategy for Schools 2015-2020 involved a total investment of 210 million euros (177.61 million GBP) by way of an Infrastructure Grant for schools. As part of the overall investment programme, the Department of Education provided €100m in grant funding to schools to address their ICT needs during 2020, €50m (42.29m GBP) in the 2019-2020 school year, and €50m (42.29m GBP) in the 2020-2021 school year. Schools were advised that they could use this funding to support the continuity of teaching and learning should a period of partial or full school closure occur arising from Public Health advice owing to COVID-19 restrictions (OECD, 2020).

Does the strategy provide a rationale for the level at which decision making to support the digital strategy and associated funding is delegated? (NB: this should also include relevant information on school/local autonomy in the country and the levers available to support strategy implementation)

As in the case of the previous strategy, funding under the new Digital Strategy for Schools will be distributed in the form of a lump sum per school, and a per capita amount based on the school enrolment.

In the case of the Digital Strategy for Schools 2015-2020, the issuing of the ICT Grant funding to schools was justified on the basis that schools "are best placed to identify the requirements of their own student cohort and to meet those requirements". DEIS schools received a 10% increase on the per capita amount above that provided for non-DEIS schools.

What evidence is there of approaches/initiatives instead of, or in addition to, a digital strategy?

In December 2021, the Minister for Education, Norma Foley TD, announced the issue of 50 million euros (42.29 GBP) in grant funding to schools to address the digital divide, the first of two major ICT projects supporting primary and post-primary schools. This EU funding was secured as part of a major investment programme for the Department of Education in the government's National Recovery and Resilience Plan (NRRP) approved by the European Council.

Under this project, funding will be paid directly to all recognised primary and post-primary schools in the free education scheme, to invest in digital infrastructure to support students who are most at risk of educational disadvantage through the digital divide. The rates will be based on pupil/student enrolment numbers and whether a school is DEIS or non-DEIS, with DEIS schools receiving double the amount of funding provided to non-DEIS schools, as below:

Primary

Enrolment	Grant – Non DEIS	Grant - DEIS
0 to 99	€5,000 (4,200 GBP)	€10,000 (8,400 GBP)
100 to 249	€8,000 (6,720 GBP)	€16,000 (13,430 GBP)
250 to 499	€13,360 (11,220 GBP)	€26,720 (11,440 GBP)
500 to 749	€22,311 (18,735 GBP)	€44,622 (37,470 GBP)
750 plus	€37,260 (31,290 GBP)	€74,519 (62,570 GBP)

Source: (Department of Education, Ireland (6 December 2021)

Post-primary

Enrolment	Grant – Non DEIS	Grant - DEIS
0 to 249	€8,000 (6,720 GBP)	€16,000 (13,430 GBP)
250 to 499	€13,360 (11,220 GBP)	€26,720 (11,440 GBP)
500 to 749	€22,311 (18,735 GBP)	€44,622 (37,470 GBP)
750 plus	€37,260 (31,290 GBP)	€74,519 (62,570 GBP)

Source: (Department of Education, Ireland (6 December 2021)

Schools will be required to use this funding for the direct benefit of their students and can consider innovative projects and programmes using digital technologies in teaching and learning depending on their own digital learning plan (details below) and approaches, including providing infrastructure such as devices on loan to students (Department of Education, Ireland (6 December 2021).

The other project for which NRRP funding is being used will supplement the delivery of high-speed broadband alongside delivery under the National Broadband Plan, and commercial provision through the Schools Broadband Programme. Given the overall funding for two NRRP projects is €63.5m (53.32m GBP) and €50 million (42.29m GBP) has been earmarked for the other project, it appears that funding for this project will be €13.5m (11.42 GBP). This is in addition to funding provided by the Schools Broadband Programme, through which the Department of Education directly funds the provision of broadband connectivity to schools at an annual cost of around €13m (10.00m GBP) (with some 98% of schools availing themselves of this programme) (Department of Education, Ireland, 16 July 2021; PDST Technology in Education website).

Which bodies take decisions about spending in the delivery chain from government to individual schools and colleges?

Funding is issued directly to schools by the Department of Education, together with frameworks to guide schools in making decisions on how to use the grants.

Overview of bodies taking decisions about technology choices

Decisions about technology choices are informed by two core factors: Department of Education guidance on how grants issued directly to schools can be used and digital learning plans developed by the schools themselves.

Under the Digital Strategy for Schools 2015-2020, all primary and post-primary schools were expected to prepare and implement a Digital Learning Plan appropriate to their own context to support improvements in teaching, learning and assessment using digital learning as part of the Whole School Plan.

A range of support was put in place to support schools, including access to continuing professional development (CPD) for individual teachers, seminars for school leaders, an online repository of teaching resources (Scoilnet), resources to support online safety, and guidance on ICT infrastructure (Inspectorate, Department of Education and Skills, June 2020).

The support on offer included The Digital Learning Planning Guidelines, which provide guidance on how the Digital Learning Framework can support the creation of a Digital Learning Plan for each school. The guidelines can also be used to support subject department and individual teacher planning and to promote digital learning at programme and cross-curricular levels. The ultimate goal for the Digital Planning Guidelines is to guide schools in embedding digital technologies into all areas of school activity (PDST Technology in Education website; Department of Education and Skills, 2020).

Specific decision areas (centralised or devolved) and links to strategies and funding

Decisions regarding the issues covered in this section are largely devolved to schools, with the exception of ETB schools.

PDST Technology in Education, which coordinates the Schools Broadband Programme, provides ICT advice and supports to first and second level schools on a range of technology related areas, including broadband, networking and wifi, cloud-based tools and applications, computing devices/tablets, ICT purchasing considerations, online and distance learning, data security, ICT infrastructure, ICT grants, ICT in the classroom, and Technical Support in schools.

PDST Technology in Education is part of the national support service, the Professional Development Service for Teachers, which operates under the aegis of the Department of Education. The functions of PDST Technology in Education were previously the responsibility of the National Centre for Technology in Education (NCTE). The NCTE was integrated into the PDST in June 2012. The PDST is managed by the Dublin West Education Centre, a statutory body funded by the Department of Education Skills which provides CPD for teachers and school communities.

The Schools Procurement Unit (SPU) provides guidance to all primary and post-primary schools (except ETB schools) on any procurement-related issue. The SPU delivers free advice and practical support to schools to help them achieve improvements in their procurement processes, practices and outcomes. Schools managed by ETBs are required to contact ETB Head Quarters for advice on procurement. The PDST Technology in Education website refers to a number of purchasing frameworks for schools (Department of Education, 10 January 2020, last updated on 16 July 2021).

Broadband connectivity

The Schools Broadband Programme, which costs the Department of Education €13m (10.00m GBP) per annum, provides an integrated set of services to schools which includes broadband connectivity. The PDST Technology in Education Broadband Service

Desk is the single point of contact for schools for all broadband related issues, providing information, advice and support to schools.

The Department of Education recently announced another project, which will supplement the Schools Broadband Programme. Costing approximately €13.5m (11.42 GBP), this project is focused on the delivery of highspeed broadband connectivity for schools across Ireland.

It is the intention of the Department to provide all primary schools with high-speed broadband connectivity by early 2023.

Digital infrastructure (including Wi-Fi, switching and cabling, servers and cloud storage and internal networking in school/college buildings)

The PDST Technology in Education website states that a wireless purchasing framework that had been in place for schools for the last four years, and which many schools and ETBs successfully used to procure Wi-Fi, has recently expired. It is not stated if or when a new purchasing framework will be introduced. However, PDST Technology in Education state that schools that are considering purchasing and installing suitable Wi-Fi in their school can seek objective advice, including technical advice, from them (PDST Technology and Education website).

PDST Technology in Education, provides ICT advice and supports to schools on networking and wifi, cloud-based tools and applications, and school broadband.

Data (interoperability, security)

No information found.

Back-office systems (the software that supports the technology)

No information found.

Accessibility (for example, audio visual)

This was an important element in the Digital Strategy for Schools 2015-2020 (Theme 1):

"In adopting ICT for teaching and learning the Department will ensure that information will be accessible to all learners in line with requirements under the UN Convention on the Rights of Persons with Disabilities. The Convention emphasises:

- The obligation to 'provide accessible information to persons with disabilities' (Article.4)
- The need for 'the design, development, production and distribution of accessible ICT' (Article.9)

- The right to education ‘without discrimination and on the basis of equal opportunity’ for persons with disabilities (Article.24)

Hardware (for example, laptops, desktops, tablets, peripherals)

The PDST Technology in Education website highlights a PC & Notebook/Laptop Framework, which enables schools to order items from the two listed suppliers, without having to seek quotes from other suppliers. This is possible because there is an Office of Government Procurement (OGP) contract in place with the two approved companies at agreed prices.

The PDST Technology in Education website notes that a Chromebook purchasing framework and an Apple purchasing framework (for Apple Devices/iPads) have recently expired.

As in the case of the wireless purchasing framework mentioned above, it is not stated if or when a new purchasing framework will be introduced, but PDST Technology in Education indicate that schools that are considering purchasing Chrome or Apple devices for their school can seek objective advice, including technical advice, from them (PDST Technology and Education website).

Software (for example, Management information systems, HR, finance, safeguarding, monitoring and filtering)

No information found.

Curriculum and business administration choices

The curriculum for Ireland's primary and post-primary schools is determined by the Minister for Education who is advised by the National Council for Curriculum and Assessment. The curriculum sets out not only what is to be taught, but how, and how learning in the particular subject area is to be assessed.

A report by the European Commission/EACEA/Eurydice (2019) on Digital Education at School in Europe, which considered curriculum approaches to digital competences under the 2015-2020 Digital Strategy for Schools, highlighted the following the follow aspects of the national curriculum:

Curriculum approaches	Subjects/Learning areas	ISCED levels
Cross-curricular theme	Embedding the use of digital technologies is now part of the	ISCED 1-3

	curriculum development process. Any new curriculum that is developed ensures that opportunities to use technology and digital media tools to learn and communicate are included.	
Integrated into other compulsory subjects	Social, personal and health education (SPHE): digital media literacy	ISCED 1-2 ISCED 3
Optional short course	Digital media literacy	ISCED 2
Optional separate subject	Computer science (being introduced from 2018 on)	ISCED 3

The Digital Strategy provides for a programme of curriculum reform which sees digital technologies embedded in all emerging curricular specifications. Computer science has been introduced at ISCED 3 level from September 2018 in 40 schools (phase 1 rollout) and will be available as an option to all schools from September 2020 (European Commission/EACEA/Eurydice, 2019).

The announcement of the development of the new Digital Strategy for Schools noted that:

- In consultation with the National Council for Curriculum and Assessment (NCCA), the Department of Education ensures that all new and revised curricular specifications include clear statements that focus on the development of digital learning skills and the use of digital technologies as a resource in achieving specific outcomes across the curriculum.
- The Junior Cycle Framework (which provides the basis for post-primary schools to plan quality, inclusive and relevant education programmes with improved learning experiences for all students, including those with special educational needs) promotes digital literacy skills through eight Key Skills (all skills have an ICT/digital component) and through Statements of Learning. In addition, in the ongoing reviews of the Primary Curriculum and of the Senior Cycle, the skills of, or skills closely related to, digital literacy have featured strongly in all discussions on future provision (Department of Education, Ireland (5 April 2021, last updated 6 April 2021).

Staff training Although detailed information regarding the new Digital Strategy for Schools is not yet available, CPD was specifically mentioned by the Minister of Education when announcing that the strategy was to be developed (Department of Education, Ireland, 5 April 2021, last updated 6 April 2021).

Developments under the Digital Strategy for Schools 2015-2020 included:

- Following a consultation process, Digital Skills was established as one of the seven core elements incorporated for the first time into the revised Teacher standards published by the Teaching Council in October 2020. The digital skills encompass digital literacy and the use of digital technologies to support teaching, learning and assessment for all learners; the integration of digital skills across the programme including opportunities for student teachers to explore new and emerging technologies. All new programmes submitted to the Council for accreditation must now be in alignment with the standards.
- The Department of Education also issued a guiding framework for teacher educators for consideration when preparing/revising their Teacher Education Programme. The framework highlights the range of knowledge and skills required by pre-service teachers to develop professional digital competencies so that they can effectively use digital technologies in teaching and learning. This framework "A Guiding Framework for Pre-Service Teachers' Professional Digital Competence" was developed in consultation with representatives of the ITE sector
- Finally, the Department of Education established the effective use of digital technologies in teaching, learning and assessment as an integral part of all department funded CPD programmes and supports (Inspectorate, 2020).

Technical support

To assist schools in managing technical support in the school, PDST Technology in Education provides a Technical Support Requirements Document, which comprises a template document that a school can modify to its own needs and then send to prospective providers, seeking quotes to provide technical support to their school. It achieves this in seven main ways:

- It helps the school quantify and review the current level of ICT infrastructure in the school
- It provides a process to prioritise what are the main ICT elements in the schools that require external support
- It helps the school to define what level and priority of technical support is required for various elements

- It helps to identify areas that may not require local technical support as they are supported via other means (for example Schools Broadband, ICT Equipment purchased with its own warranty)
- It helps the school find a balance between what the school can support from its own resources and where additional external technical support is required
- It sets an expectation as to what level of service is required (for example remote support (in addition to a call out service) is recommended by PDST Technology in Education as an important and cost-effective aspect of the service)
- As all technical support companies must quote based on a common set of requirements it should simplify the evaluation of their responses (PDST Technology in Education website)

Cyber security

PDST Technology in Education provides information and advice on cyber security and data security, as well as a set of hosted services including content filtering, and security services including anti-virus control and a centralised firewall.

How (and by how much) infrastructure is funded, and how this investment is supported and delivered

On 1 February 2022, the Irish Government launched a new national digital strategy, Harnessing Digital – The Digital Ireland Framework, is set out across four core dimensions, which are in line with the four fundamental points of the EU's Digital Compass: Digital Transformation of Business; Digital Infrastructure; Skills; and Digitalisation of Public Services. The strategy aims to:

- Make connectivity available to everyone, including through the National Broadband Plan, Remote Working Hubs and Broadband Connection Points, with a target of having all Irish households and businesses covered by Gigabit network no later than 2028 and all populated areas covered by 5G no later than 2030.
- Provide digital skills for all – from school, to further and higher education, to life-long learning, with a target of increasing the share of adults with at least basic digital skills to 80% by 2030.
- Ensure widespread access and use of inclusive digital public services, with a target of 90% of services to be consumed online by 2030.
- Help small businesses benefit from digital opportunities by providing grants and assistance, with a target of 90% of SME at basic digital intensity by 2030 and 75% enterprise take-up in cloud, AI and big data.

- Invest in cyber-security to protect Irish citizens and businesses, including increased resources for the National Cyber Security Centre.
- Ensure a modern and well-resourced regulatory framework (Department of the Taoiseach, 1 February 2022).

Evidence of the cost effectiveness of different models

No evidence of the cost effectiveness of different models has been found.

Italy

Summary and gaps

The Italian National Plan for Digital Schools Piano Nazionale Scuola Digitale (PNSD) was launched by the Ministry of Education, University and Research (MIUR) at the end of 2015. The PNSD comprised 35 different actions that address five key areas of intervention: tools, skills, content, staff training and supporting measures (for example innovative libraries, digital weeks, fab labs), which were intended to be implemented up to 2020. It is unclear whether this digital strategy for schools will be extended or replaced with a new strategy. One recent development that has implications for the use of technology in schools is the Digital Italy 2026 Plan (MITD, 2021), which includes commitments to improve connectivity and interoperability in the school sector.

The PNSD was allocated 1.1 billion euros (0.93 billion GBP) in funding from existing sources. Of this, 650 million euros (549.73 million GBP) was spent on digital infrastructure, including broadband and Wi-Fi connection. The remainder of the budget was directed to a range of measures, which included initiatives designed to facilitate the acquisition of digital competences and teacher training. Much of the funding was devolved directly to schools which were required to submit project proposals in the five areas of innovation in response to open competitions.

There is evidence to suggest that the projects undertaken by schools lacked coordination and organicity, and that the use of a non-systematic and voluntary-based approach could produce very mixed outputs with superficial changes.

Overview of school system

Education is compulsory between the age of six and 16. Compulsory education consists of primary education (age six to 11 years), lower secondary education (age 11 to 14 years) and upper secondary education (age 14 to 16 years, with the option of continuing until age 19) (Eurydice: National Education Systems: Italy).

During upper secondary education, students complete an obligatory two years of general studies followed by an optional three years of specialised education, which comprises either general education at a liceo (akin to a British grammar school) or vocational education at an istituto, which is essentially a vocational school (Eurydice: National Education Systems: Italy).

Funding

Primary education is free of charge, while schools offering lower and upper secondary education can be either state schools or non-state schools that have a status equal to state schools (called paritarie schools). Such non-state schools can be run by public bodies, usually local authorities such as municipalities and provinces, as well as by private subjects. Their equal status depends on meeting some specific conditions established by the State law. There are also private schools that are not part of the Italian education system (Eurydice: National Education Systems: Italy).

The State directly finances State schools through funds included in the budget of the MIUR. Paritarie schools, as they are part of the national education system, receive state funds according to specific criteria established by regulations. Regulations also establish that priority must be given to those schools run by no-profit entities (Ministerial Decree of 21 May 2007; Eurydice: National Education Systems: Italy).

Brief description of digital strategy

The Italian National Plan for Digital Schools (Piano Nazionale Scuola Digitale, PNSD) was launched by MIUR at the end of 2015. The aim of the PNSD was to set up a comprehensive innovation strategy across Italy's school system and “bring it into the digital age”.

The plan comprised 35 different actions that address five key areas of intervention:

- Tools
- Skills
- Content
- Staff training
- Supporting measures (for example innovative libraries, digital weeks, fab labs) (Bottino, 2020).

The actions were intended to be implemented up to 2020 and the plan was in line with the Italian digital agenda strategy (CEDAFOP, 2017).

It is not clear whether the PNSD will be extended or a new digital strategy for schools will be introduced. However, the Digital Italy 2026 Plan (MITD, 2021) includes enhancements of connectivity and interoperability in the school sector.

Priorities and timescales

The PNSD aims to implement interventions that have an impact on the structuring of classes and laboratories, on their equipment, on the definition of contents and skills, as well as on the production of materials and pedagogical plans (Bottino, 2020).

According to van der Vlies (2020), the PNSD key priorities are as follows:

- Vision on digital schools: digital opportunities as enabling tools, connectors and drivers of change projects categorised in: tools, skills and content, training, and supporting measures
- Access: ‘right to Internet’, fibre for ultra-wide bandwidth for schools
- Digital environments, guidelines for BYOD (“bring your own device”) policies
- Digital profile for students and teachers
- Unique authentication system
- Use of digital technology in school administration and teaching processes
- Common framework for digital skills of students, update technology curriculum
- Bridge digital divides
- Promote science, technology, engineering, arts and maths (STEAM) careers
- Promote innovation, diversity and sharing of educational content
- Minimum standards for e-interoperability
- Promotion of open educational resources
- In-service training for didactic and organisational innovation, technical assistance for schools

The Digital Italy 2026 Plan (MITD, 2021) includes commitments to improve connectivity and interoperability in the school sector.

Is there funding attached to strategies/initiatives and how is this devolved?

The Plan was endowed with 1.1 billion euros (0.92 billion GBP) in funding from existing sources. A total of 650 million euros (5.45 million GBP) was spent on digital infrastructure, including broadband and Wi-Fi connection. The rest was directed to fostering the acquisition of digital competences, teacher training for innovative practices, and other accompanying measures (European Commission 2016; Bottino, 2020).

To receive funds in the five areas of intervention (tools, skills, content, staff training, and supporting measures) schools were required to submit project proposals to open competitions (Bottino, 2020).

Does the strategy provide a rationale for the level at which decision making to support the digital strategy and associated funding is delegated? (NB: this should also include relevant information on school/local autonomy in the country and the levers available to support strategy implementation)

The Italian public administration has a decentralised organisation. The state has exclusive legislative competences on the general organisation of the education system: minimum standards of education, fundamental principles, school staff, quality assurance, state financial resources, foreign schools and cultural institutions in Italy. The regions, through their relevant offices, define the school network within their own territories, fix the school calendar and contribute to non-state schools. Moreover, regions have exclusive legislative power on the organisation of the regional vocational education and training system. Local authorities are responsible for the establishment, aggregation, merging and the closing down of schools, the interruption of teaching for serious and urgent reasons, and the setting up, control and dissolution of school collegiate bodies. Schools have administrative and managing autonomy. Within the general frame of school autonomy set at national level, schools define the curricula, widen the educational offer, and organise teaching (school time, groups of pupils, etc.) (Eurydice: National Education Systems: Italy [accessed 16/03/2022]).

Apart from broadband connectivity, it appears that PNSD was largely focused at school level. The main drivers of the adopted strategy were to significantly increase the funds invested, to target schools and teachers eager and ready to initiate change, to stress pedagogical uses of technology and to conduct experiments (Bottino, 2020).

What evidence is there of approaches/initiatives instead of, or in addition to, a digital strategy?

In 2021 it was announced that the European Commission had approved, under EU State aid rules, 325 million euros (274.87 million GBP) of public support to connect 12,000 schools in Italy to very high-speed internet by 2025. The scheme aims to promote the deployment of a network able to provide upload and download speeds of 1 gigabit per second (Gbps) to Italian schools (European Commission, January 2021).

The measure notified by Italy to the Commission only targets schools where no broadband network offering download speed above 300 megabits per second (Mbps) is currently in place or planned in the near future. The Italian Government considers that very high-speed internet connection is necessary to provide online educational services, which have become essential in the context of the COVID-19 pandemic (The European Sting, January 2021).

The Italian authorities have developed a comprehensive mapping of available infrastructure and public consultation in order to determine the target areas and the eligible schools (The European Sting, January 2021).

Which bodies take decisions about spending in the delivery chain from government to individual schools and colleges?

PNSD was largely targeted at school level.

Overview of bodies taking decisions about technology choices

MIUR authorised decision making at school level via the PNSD.

Specific decision areas (centralised or devolved) and links to strategies and funding

Broadband connectivity

Since 2015, PNSD included a commitment to broadband connection in every school building (CEDEFOP, 2017). The Digital Italy 2026 Plan (MITD, 2021) aims to provide 1 Gbps connectivity for everyone, including schools, by 2026.

Digital infrastructure (including Wi-Fi, switching and cabling, servers and cloud storage and internal networking in school/college buildings)

A key aspect of the PNSD plan was the structural investments designed to create new physical places (labs, educational environments and libraries) for technological and methodological innovation. Since 2015, different notices have been published with the aim of improving the digital infrastructure in schools and the related financial resources have been allocated. Notices regarding the following issues have been released: broadband connection and Wi-Fi, local lab for the high school, creative atelier for the primary school, and digital libraries. Due to these measures, and to the allocation of several million euros, it is anticipated that the following goals will be reached in the short/medium term: broadband and Wi-Fi coverage available in every school building; creation of labs and rooms for innovative and lab-oriented education (flipped classroom);

and the creation of libraries technologically ‘boosted’ in almost every Italian school of all types and at all levels (CEDEFOP, 2017).

Data (interoperability, security)

The PNSD included minimum standards for interoperability.

A core aim of the Digital Italy 2026 Plan (MITD, 2021) is to make all public data interoperable. The possibility to have public databases communicate is a fundamental building block in the simplification of bureaucratic procedures: interoperability enables administrations to save on data harvest and elaboration times and improves citizens’ life quality by allowing them to avoid a time-consuming collection of certificates.

The Digital Italy 2026 Plan (MITD, 2021) also aims to provide 70 % of Italians with a unique digital identity by 2026. Digital identity will become the main tool to access all public services. There are several benefits including: a free digital domicile to receive communications from Public Administration; a single platform where citizens and administrations can communicate, also on mobile; simple, transparent and traceable payments to Public Administration.

Back-office systems (the software that supports the technology)

According to the Digital Italy 2026 Plan (MITD, 2021), 75 % of central and local Public Administrations will be using cloud services by 2026. Cloud is viewed as having three main advantages: it is safer because it reduces the fragmentation of services; it costs less because it eliminates both maintenance expenses and unexpected charges arising from inefficiencies; it improves efficiency due to its scalability in regards to the fluctuation of workloads because it facilitates constant updating.

Accessibility (for example, audio visual)

With regard to inclusion, targeted policies have been included in Cl@ssi 2.0. This is the case of the New Technologies and Disabilities (NTD) project, started in 2006 and co-funded with a budget of 10 million euros (10.38 million GBP) by the Ministry of Education and the National Centre for ICT in Public Administration (CNIPA) (European Commission, January 2021).

Hardware (for example, laptops, desktops, tablets, peripherals)

The PNSD includes a “bring your own device” (BYOD) policy. BYOD means that students bring their own devices and connect them to the Internet (Wi-Fi) at school.

Software (for example, Management information systems, HR, finance, safeguarding, monitoring and filtering)

No information found.

Curriculum and business administration choices

In the PNSD, a specific action is devoted to programming as a way of bringing computational and logical thinking to all students. The main rationale for introducing computational thinking is to foster twenty-first century skills and to move students from being passive users to active producers of technologies. While it is still unclear how the ministry will reform the current curriculum guidelines to include computational thinking, a recent unanimous vote of the parliament has committed the government to finalise it by 2022. The orientation is to introduce computational thinking as a transversal subject in primary school and within the existing subjects of Mathematics and Technology in lower secondary school, and of not providing for the introduction of a new subject (Bottino, 2020).

Staff training

A training plan targeting the training of the entire school staff in the skills needed to manage the schools' digital transformation has been a key strategic element of the PNSD (CEDEFOP, 2017).

The PNSD was based on the premise that an "ICT culture" throughout the school has to be created and nurtured (Bottino, 2020).

The orientations followed over time for the introduction of ICT in schooling characterised also teacher training programs and initiatives. The Italian policy for ICT in Education has moved from centralised training initially oriented to the introduction of elements of informatics and the development of skills in the use of technology to training that addresses the educational use of ICT in different disciplinary contexts (Bottino, 2020).

The PNSD has resulted in heterogeneity in terms of how this training has been carried out since it has been often linked to local/regional initiatives. An overall evaluation of these initiatives has not been carried out so far (Bottino, 2020).

Technical support

The PNSD included the introduction of dedicated professional roles responsible for implementing the PNSD in each school. Since December 2015, each Italian school has (or should have) a 'digital catalyst' and an innovation team of teachers exclusively devoted to promoting digital innovation from a methodological, educational and technological point of view. A digital catalyst is a teacher, appointed by the principal in each school, who is responsible for the PNSD implementation and, together with a team of three or four teachers aiding her/him, form the innovation team.

The scope of the digital catalyst and her/his team, focuses on three areas: (i) methodological and technological training of colleagues; (ii) involving and motivating the whole school community in digital innovation; (iii) planning and spreading, in the school and among colleagues, sustainable methodological and technological solutions (CEDEFOP, 2017).

Cyber security

No information found.

How (and by how much) infrastructure is funded, and how this investment is supported and delivered

The Italian Strategy for Ultra Broadband Towards the Gigabit Society, May 2021, has seven intervention areas: a) Plan for white areas, b) Voucher plan, c) Plan Italy 1 Giga, d) Italy 5G Plan, e) Connected Schools Plan, g) Connected Health Plan, and h) Minor Islands Plan.

The Plan Italy 1 Giga, aims to provide 1 Gbps in download and 200 Mbps upload speeds in grey and market failure areas. The Italy 5G Plan aims to incentivise the deployment of 5G mobile networks in areas of market failure.

A core aim of the Digital Italy 2026 Plan (MITD, 2021) is to make all public data interoperable. The Digital Italy 2026 Plan (MITD, 2021) also aims to provide 70 % of Italians with a unique digital identity by 2026. Digital identity will become the main tool to access all public services.

Plan Italy 1 Giga has a planned allocation of 3.8 billion euros (3.19 billion GBP), while the Italy 5G plan has an allocation of 2.02 billion euros (1.69 billion GBP).

The Italian National Recovery and Resilience Plan allocates EUR 6.7 billion (5.62 billion GBP) for the implementation of the Strategy for Ultra Broadband. The plan provides allocations for the following 5 projects:

- Italy 1 Giga
- Italy 5G
- Connected schools, aiming to provide the state-of-the-art connectivity (at least 1 Gbps) to approximately 9,000 schools

- Connected health care facilities, which intends to cover approximately 12,000 hospitals and healthcare facilities (at least 1 Gbps and up to 10 Gbps connectivity)
- Connected smaller islands, aiming to deliver adequate connectivity to 18 smaller islands through submarine fibre cables (European Commission, Broadband in Italy, website accessed 24/02/2022)

In 2021 it was announced that the European Commission had approved, under EU State aid rules, 325 million euros (274.9 million GBP) of public support to connect 12,000 schools in Italy to very high-speed internet by 2025 (European Commission, State aid: Commission approves €325 million public support to provide schools in Italy with very high internet speeds January 2021).

Evidence of the cost effectiveness of different models

There are no studies available in English that have looked at cost-effectiveness; however, an evaluation conducted after the first year of PNSD highlighted several potential problems, including: the complexity of the implementation programme and the many professional and managerial responsibilities assigned to schools; the 'parallel' launching of the different action plans; and, most importantly, the lack of a comprehensive and systematic plan for the continuous training of teachers and school managers who implement digitalisation projects (CEDEFOP, 2017).

These concerns are echoed in a more recent assessment of the PNSD by Bottino (2020). This suggests that:

- The adoption of innovative teaching methodologies was suggested but left to the initiative of individual school projects, as well as the establishment of specific connections with curricular subjects. The drafting of guidelines on such issues and the implementation of the related teacher training activities have been considered but not implemented in a systematic way. As in the past, this approach could produce very mixed outputs with superficial changes due to its non-systematic (proposals are left to single school initiatives) and voluntary-based approach.
- The scope of the PNSD is ambitious, and one of its main problems is that a systemic approach has so far been lacking. At present, the plan does not significantly change school curricula or assessment approaches and some of the proposed innovations, like the introduction of computational thinking, have been so far optional activities.
- Moreover, schools have been left alone in the elaboration of the various projects to be presented in order to obtain funds to implement the different actions of PNSD and often such projects lacked coordination and

organicity. The support offered to schools both to produce effective and coordinated projects and to progressively group into networks to capitalise on expertise is a crucial factor without which not even an ambitious reform such as the PNSD can succeed (Bottino, 2020).

Japan

Summary and gaps

The Japanese Government has launched several initiatives to promote the use of digital technology in education, including the GIGA (Global and Innovation Gateway for All) School Program, which was launched in 2019. The key aims of this programme include one ICT device per one student; the integrated preparation of high-speed, high-capacity ICT networks in schools; and ensuring teachers and students have the ability and confidence to use ICT. Japan's Ministry of Education, Culture, Sports, Science and Technology (MEXT) originally aimed to implement the GIGA programme by the end of March 2024, but in 2020 the plan was moved forward by three years due the impact of school closures in response to the COVID-19 pandemic.

In 2019, the government allocated 231.8 billion JPY 1.52 billion GBP) for the provision of one ICT device per one student and the integrated preparation of high-speed, high-capacity ICT networks in schools. In 2020, in response to the expansion of school closures due to COVID-19, a further 229.2 billion JPY (1.5 billion GBP) was allocated to the programme. MEXT's budget request for the 2021 fiscal year included 427 million JPY (2.8 million GBP) for developing online training programmes for teachers in how to use ICT in their lessons.

The GIGA programme not only subsidises but also guides technology procurement, promotes the use of high-quality digital textbooks and teaching materials, and publishes guides on technology education and digitally enabled teaching of traditional subjects. There are no studies of the cost-effectiveness of Japan's GIGA School Programme available in English, but the goal of "one device per one student" has largely been achieved. Although OECD surveys in 2018 showed that Japan was the country least utilising digital equipment in schools, by March 2021 MEXT had completed just under 98 % of their planned delivery of hardware devices to local governments.

Overview of school system

Education is compulsory between the age of six and 15. Compulsory education consists of six years of elementary school (ages 6 to 12) and three years of lower secondary school (ages 12 to 15) (Japanese Ministry of Education, Culture, Sports, Science and Technology, n.d.).

Almost all Japanese students continue to upper secondary school (ages 15 to 18) for a further three years. Most enrol at an academic upper secondary school, but there are also vocational options: specialised vocational high schools, colleges of technology, and specialised training colleges. In addition, there are integrated schools, which combine academic and vocational coursework (Japanese Ministry of Education, Culture, Sports, Science and Technology, n.d.; NCEE, n.d.). Public primary and lower secondary schools do not charge tuition, and government financial support for families earning below an annual income threshold makes public upper secondary school essentially free to all apart from the highest income families (NCEE) (n.d.).

Regarding the private education sector in Japan, approximately 1% of primary schools, 7% of lower secondary schools and 25% of upper secondary are classified as private (OECD, 2018; NCEE, n.d.).

Funding

Japan funds its public schools through a combination of support from the national, prefectural and municipal governments. At a national level the Ministry of Education, Culture, Sports, Science and Technology (MEXT) allocates funding to prefectural and municipal authorities for schools. In public compulsory education, prefectures play a significant role in resource and personnel management. For example, the prefectures pay two-thirds of teachers' salaries, while the national government pays one-third. Municipalities are responsible for the supervision and day-to-day operation of schools.

The Japanese Government also uses public funds to support private education, paying 50 % of private school teachers' salaries and providing capital grants to cover specific costs such as new buildings and equipment. Private schools can create specialised programs within a framework set by the prefecture; the governor of a prefecture must approve applications to establish private schools (NCEE, n.d.).

Brief description of digital strategy

The Japanese Government has launched several initiatives and plans to promote the use of technology and innovation in education (Mckinsey and company, 2021; van der Vlies, 2020). Recently, the most prominent has been the GIGA School Program, which was launched in 2019 as part of a government push toward a post-information society called Society 5.0, incorporating cyberspace such as AI, big data and the Internet of Things (Mckinsey and company, February 2021; UNICEF, October 2021).

The aims of the programme are as follows:

- Realise an educational ICT environment optimised for each child, including those with special needs, and ensure further development of their abilities.
- Maximise the power of teachers and students through the best mix of past educational practices and cutting-edge ICT technology (MEXT, September 2020).

Key elements of the programme are one ICT device per one student, and the integrated preparation of high-speed, high-capacity ICT networks in schools (UNICEF, October 2021).

MEXT originally targeted fully implementing the GIGA programme by the end of March 2024, but in 2020 the plan was moved forward by three years, partly so schools could be better prepared should COVID-19 necessitate further school closures (MEXT, September, 2020).

In 2021 MEXT placed a particular emphasis on CPD for teachers in order to improve their confidence and skills in using ICT in the classroom.

Priorities and timescales

The government initially introduced the GIGA School Program in 2019 to digitalise education among country's nearly 13 million primary and secondary school students and in its almost 35,000 schools. MEXT originally aimed to fully implement the GIGA school programme by the end of March 2024. However, after only 5% of municipal education authorities were prepared to use online learning when schools closed during the COVID-19 crisis, the programme was brought forward by three years and strengthened in 2020, with a particular emphasis on the early realisation of one computer per student and the development of an ICT environment in all students' homes. This was partly so that schools could be better prepared should COVID-19 necessitate school closures again (MEXT, September 2020).

The priorities of the accelerated programme were/are as follows:

- A device for every student;
- High-speed internet for all schools;
- Equipment to ensure that every child can work from home;
- An ICT infrastructure for schools including prototypes of online learning systems and systems to standardise educational data collection (Japanese Ministry of Education, Culture, Sports, Science and Technology' (MEXT, September 2020; NCEE, n.d.).

In addition to providing hardware and connectivity to students through GIGA MEXT's recognises that there is a need to improve confidence to use ICT among teachers and students and, in 2021, placed an emphasis on creating online training programmes for teachers in how to use ICT in their lessons (UNICEF, October 2021).

Is there funding attached to strategies/initiatives and how is this devolved?

The budget for the Giga School Programme is administered by MEXT. In 2019 the budget was 231.8 billion JPY (1.49 billion GBP). After that, in response to the expansion of school closures due to COVID-19, the government allocated a further 229.2 billion JPY (1.47 billion GBP), a total of 461 billion JPY (2.95 billion GBP) in 2019-2010 (UNICEF, October 2021, can be broken down as follows:

	2019 **JPY**	**2020** **JPY**	**Total** **JPY**
Supporting for maintaining computers for students	No evidence of funding	No evidence of funding	No evidence of funding
Realising "1 computer per student" Supporting computer maintenance for students at the compulsory education level.	102.2 billion (0.67 billion GBP)	195.1 billion (1.28 billion GBP)	297.3 billion (1.95 billion GBP)
Assistive computers for disabled students Supporting provision of input/output assistive computers for children with visual, auditory, and physical disabilities.	No evidence of funding	No evidence of funding	1.1 billion (0.0072 billion GBP)
Developing a school-wide network environment	No evidence of funding	No evidence of funding	No evidence of funding
Support for maintaining the school LAN environment and power supply cabinets (including high schools).	129.6 billion (0.85 billion GBP)	7.1 billion (0.046 billion GBP)	136.7 billion (0.90 billion GBP)

Placing GIGA school supporters			
Supporting the placement of local governments' ICT engineers to promote ICT in schools (including high schools).	No evidence of funding	10.5 billion (0.069 billion GBP)	10.5 billion (0.069 billion GBP)
Learning environment at home for emergency	No evidence of funding	No evidence of funding	No evidence of funding
Devices for learning at home JPY Supporting the lending of LTE communications equipment (mobile routers) by local governments to households that do not have Wi-Fi.	No evidence of funding	No evidence of funding	14.7 billion (0.096 GBP)
Distance learning capabilities of schools Supporting the installation of communication devices such as cameras and microphones to schools (including high schools).	No evidence of funding	No evidence of funding	0.6 billion (0.0039 billion GBP)
Online system for ensuring learning Research to introduce a platform for learning and assessment at school and at home using ICT.	No evidence of funding	No evidence of funding	0.1 billion (0.00065 billion GBP)

Source: MEXT, September, 2020

MEXT's budget request for the 2021 fiscal year included 427 million JPY (2.80 million GBP) for creating online training programmes for teachers in how to use ICT in their lessons (UNICEF, October 2021).

Does the strategy provide a rationale for the level at which decision making to support the digital strategy and associated funding is delegated?

(NB: this should also include relevant information on school/local autonomy in the country and the levers available to support strategy implementation)

In Japan, decision making is managed through the three levels of government: national, prefectural, and municipal. At the national level, MEXT is responsible for establishing the national curriculum, operating teacher and administrator certification programs and pay scales, developing requirements for setting up schools and developing periodic plans that outline objectives for improvement as well as indicators of progress toward those objectives. The ministryalso allocates funding to prefectural and municipal authorities for schools (NCEE, n.d.).

Prefectures play a significant role in resource and personnel management. At the prefectural level, there is a board of education composed of five members appointed by the governor. This board is responsible for appointing teachers to primary and lower secondary schools and funding municipalities, which are responsible for the supervision and day-to-day operation of schools. Within municipalities there are boards of education appointed by the mayor. These boards are responsible for making recommendations to the prefectural board of education on teacher appointments, choosing textbooks from the MEXT-approved list, conducting in-service teacher and staff professional development, and overseeing the day-to-day operations of primary and lower secondary schools. In the schools, principals are responsible for planning the school curriculum, based on the national curriculum, and for managing the schools' day-to-day activities. Teachers are responsible for determining how to teach the curriculum and for creating lesson plans, as well as being in contact with parents (NCEE, n.d.).

What evidence is there of approaches/initiatives instead of, or in addition to, a digital strategy?

Starting in April 2022, MEXT allocated 1.1 billion JPY (6.4 million GBP) to enable selected primary and lower secondary schools to join the Science Information Network (SINET) to accelerate Japanese schools' ICT development. SINET is the primary Japanese academic network for more than 800 universities and research institutions (see https://www.sinet.ad.jp/en/aboutsinet-en) (United States International Trade Administration, December 2021).

In 2020, MEXT allocated 0.5 billion JPY (3.27 million GBP) to support empirical studies to identify ways to:

- Effectively utilise cutting-edge technology and establish a diverse communication environment to realise the GIGA School Concept

- Support municipalities to advance ICT environments (MEXT, 2020)

Which bodies take decisions about spending in the delivery chain from government to individual schools and colleges?

MEXT allocates funding to prefectural and municipal authorities for schools. Prefectural and municipal authorities appear to have a substantial degree of autonomy in decisions on expenditure. Thus, for example, even ahead of the recent GIGA programme, some municipalities had already taken the decision to invest in the use of digital technology in education. Among them, the city of Toda in Saitama Prefecture actually adopted policies similar to the GIGA programme, involving distributing PCs to all students (starting from 2016), ensuring internet access, including providing mobile routers to households without net access, and training teachers. Apparently, the use of digital technology in education was not pursued before because of tight local government budgets and because traditional teaching methods had been successful, as seen in international test scores (The Japan Times, March 2021).

Overview of bodies taking decisions about technology choices

Generally, prefectures and municipalities have the responsibility for digital infrastructure in schools. In the case of the GIGA, the programme not only subsidises but also guides technology procurement, promotes the use of high-quality digital textbooks and teaching materials, and publishes guides on technology education and digitally enabled teaching of traditional subjects (Mckinsey and company, February 2021).

In the case of the GIGA aim of providing an environment that allows every child to study online at home, MEXT (September 2020) announced that it was going to contact suppliers after establishing demand nationwide and would arrange for specialists to give advice directly to local governments, etc. This suggests that local government plays an important role in technology choices. Further evidence of this is provided by a partnership in 2020 between Sagamihara City and Cisco Systems to deploy Meraki, a cloud-based school network solution that was consistent with the GIGA school concept, across all 105 local schools (Mckinsey and company, February 2021).

Specific decision areas (centralised or devolved) and links to strategies and funding

Broadband connectivity

The Japanese Government's GIGA programme is specifically targeted at the development of a national ICT education infrastructure. The main pillar of this aspect of the programme is "cloud by default," i.e., the establishment of high-speed and large capacity IT network connections to each school (United States International Trade Administration, December, 2021; van der Vlies, 2020; MEXT, 2019).

Digital infrastructure (including Wi-Fi, switching and cabling, servers and cloud storage and internal networking in school/college buildings)   Support for maintaining the school LAN environment and power supply cabinets has been a key element of the GIGA programme, with 136.7 billion JPY (0.88 billion GBP) invested in this in 2019-2020.

Data (interoperability, security)

MEXT is looking to develop a “smart school scheme” in which academic and administrative data can be more effectively utilised to help students, teachers and parents (United States International Trade Administration, December 2021).

According to a recent report by Mckinsey and company (February 2021) on the current state of digital in Japan, local privacy regulations pose challenges for cloud learning solutions in schools. Although the GIGA programme promotes cloud adoption to a certain extent, it has prioritised distribution of computing devices to each student and improvement of the network environment, without setting a clear mandate for cloud adoption. Since the COVID-19 crisis in 2020, the promotion of ICT systems in schools has gained greater political attention, but personal information protection ordinances of local governments have been a barrier: local regulations differ by jurisdiction, with the majority prohibiting online access from computer devices that handle personal information. While driven by the desire to protect individuals’ privacy, the complexity and multiplicity of such provisions present a major impediment, particularly in implementing remote-based education at scale.

Back-office systems (the software that supports the technology)

MEXT (September, 2020) highlights the importance of building an ICT system for education to:

- Enable the complete use of ICT by developing and verifying prototypes for online learning systems that will ensure learning as well as standardizing educational data including the codification of the National Curriculum Standards.
- Reduce teachers’ burden for preparing classes and students’ assessments, and lead to work- style reform at schools by promotion of adopting ICT system such as integrated support system for school affairs.

Accessibility (for example, audio visual)

MEXT (September 2020) places a particular emphasis on accessibility for all children, including those who have special needs. For example, MEXT provides assistive computers which support input/output for children with visual, auditory, and physical disabilities. MEXT also supports the rental of high-speed communications equipment (mobile routers) by local governments to households that do not have Wi-Fi facilities. Moreover, to support children/students in low-income households, special additional payments have been made to help cover communication costs using existing subsidy programmes, so that they can continue studying at home.

Hardware (for example, laptops, desktops, tablets, peripherals)

Japan’s goal of “one device per one student” has largely been accomplished. As of March 2021, MEXT had completed 97.6 % of their planned delivery of hardware devices to 1,769 local governments (United States International Trade Administration. December 2021).

Software (for example, Management information systems, HR, finance, safeguarding, monitoring and filtering)

No information found.

Curriculum and business administration choices

During school closures due to covid between March 2020 and June 2020, MEXT launched an online platform (Children’s Learning Support website) and provided online educational content. The portal site includes learning content for students from preschool to high school (for example videos, audio files, downloadable workbooks, useful links, materials for teachers). The content was collected both from government sources and private sources (for example, publishing companies, private education companies, educationTV channels, museums). The content is organised by subject and by grade, but also organised by topic (for example, how to make face masks). Following the reopening of schools, the portal continues to evolve with new content being added regularly. (UNICEF, October 2021).

In conjunction with the next revision of textbooks in 2024, MEXT plans to implement “digital textbooks” at all elementary schools in Japan (United States International Trade Administration. December 2021).

Staff training

The OECD reported in 2018 on a range of factors related to Japan’s ICT capacity, mainly focusing on ‘readiness’ of teachers to deliver learning in a blended and more individualised manner. This highlighted the below-OECD-average confidence and skills of Japan’s teachers in terms of ‘digital readiness’. In 2021 MEXT prioritised CPD for teachers in order to improve their confidence and skills in using ICT in the classroom (UNICEF, October 2021).

Technical support

As previously noted, GIGA has invested significant funding into supporting the placement of local governments' ICT engineers to promote ICT in schools.

Cyber security

MEXT established its first "Guidelines for IT Security Policy in Education" in 2017 and revised them in May 2021. The revised policy emphasises that local governments/schools should address security measures including implementation of multi-factor authentication, SSO (single sign on), and restricting the connection of students' terminals to school access points to secure usage only. This indicates that the ideal network environment for schools will not require network isolation/division for school administration and academic usage. LBO (Local Break Out) is suggested to offload the concentrated data traffic connected to internet via school districts' servers and route it directly to the internet (United States International Trade Administration, 2021).

How (and by how much) infrastructure is funded, and how this investment is supported and delivered

In January 2016, the Japanese Government disseminated information on the Fifth Basic Plan for Science and Technology (2016–2020). The initiative is called "Society 5.0", and it seeks to create a sustainable society and contribute to the safety and comfort of individuals based on a specific cyberphysical system. Society 5.0 defines a system of systems. In it, several systems (such as energy management and highway transportation systems, among others) are connected on the Internet for the mitigation of both local and global social problems (such as the reduction of carbon emissions). This new model of society is established in IT infrastructures, which include networks, cloud computing, data centres and big data. In Society 5.0, a huge amount of information from sensors in physical space is accumulated in cyberspace. In cyberspace, this big data is analysed byAI, and the analysis results are fed back to humans in physical space in various forms. Infrastructure integration within Society 5.0 revolves around high-speed broadband connections (Narvaez Rojas et al., 2021; Cabinet Office, Government of Japan, website accessed 24/02/2022).

The aims of Society 5.0 are promoted through a series of plans setting out immediate priorities. The Sixth Basic Plan for Science, Technology and Innovation (STI) was adopted on April 1, 2021 with three main themes: (1) social structural reform, (2) fundamental strengthening of research capacity, and (3) development of human resources to support a new society. It includes provision for the development and R&D of next-generation infrastructure, beyond 5G, supercomputers, space systems, quantum technology, semiconductors, and data/AI utilisation technologies. This R&D will be supported by a 30 trillion JPY (194.2 billion GBP) investment from government, with the expectation of industry investing 90 trillion JPY (584.4 billion GBP) (Office of Science and Innovation Tokyo, 2021).

Evidence of the cost effectiveness of different models

There are no studies of the cost effectiveness of the GIGA programme (or previous strategies) available in English that looked at but Japan’s goal of “one device per one student” has largely been accomplished.

Netherlands

Summary and gaps

The administration of Dutch schools is highly decentralised, with schools being largely funded by governmental block grants for staffing and operating costs. School boards oversee the implementation of legislation and regulations in schools and are responsible for employing teachers and other staff, spending decisions (including technology), curriculum and the general internal organisation.

Currently there is no strategy for digital education in the Netherlands. However, a digitalisation agenda for primary and secondary education was announced in 2019 and the Dutch Digitalisation Strategy 2.0 (Ministry of Economic Affairs and Climate Policy), which was introduced in the same year, includes digital skills in education (European Commission/ EACEA/ Eurydice, 2019).

The digitalisation agenda for primary and secondary education focuses on five key themes, which are also included in the the Dutch Digitalisation Strategy 2.0: Innovation among teachers, school heads and administrators by learning together and with other parties; digitally literate pupils and teachers; digital teaching materials that work for users; secure, reliable and future-proof infrastructure; and ongoing consideration of ethical issues relating to the use of digital technology in education.

Overview of school system

Education is compulsory in the Netherlands between the ages of five and 16. While compulsory education starts at age five, most children (98%) enter primary education at age four. Primary schools cater for children aged four to 12. At the age of 12 children go to one of the following types of secondary education:

- Preparatory vocational secondary education (vmbo), which lasts 4 years
- General secondary education (havo), which lasts 5 years
- University preparatory education (vwo) – which last 6 years (Eurydice: National Education Systems).

Students are assigned to one of these educational ‘tracks’ based on the advice of their primary school teacher and end-of-primary tests. Secondary schools have the freedom to delay selection through “bridge” classes in the first years of secondary school. From 16 to 18, all young people must attend some form of education for at least two days a week. Young people up to age 18 must attend school until they obtain basic qualifications (Eurydice: National Education Systems).

Funding

There are both public and private institutions at all levels of the education system; the private institutions are mostly based on religious or ideological principles. Public and private institutions are funded on an equal footing, which means that government expenditure on public educational institutions must be matched by expenditure on private, government-funded educational institutions (Eurydice: National Education Systems).

The Ministry of Education, Culture and Science administers almost all central government expenditure on education. The relationship between schools and the ministry is characterised by a large measure of institutional autonomy. Schools qualify virtually automatically for funding, provided they meet the quality standards and funding conditions imposed by law for the school system as a whole. Every year, all government-funded educational institutions receive block funding to meet their personnel and running costs. They are free to decide how to use this money (Eurydice: National Education Systems).

Funds are channelled from the ministry to educational institutions both directly and indirectly. The main flows of indirect funding are via the municipalities, for example to fund primary and secondary school accommodation (Eurydice: National Education Systems).

Brief description of digital strategy

Although the Netherlands does not have a digital strategy for education, the government has set a digitalisation agenda for primary and secondary schools and has included schools in the Dutch Digitalisation Strategy 2.0 (Ministry of Education, Culture and Science, 2019; van der Vlies, 2020).

The digitalisation agenda for primary and secondary schools focuses on five key themes, which are also included in the the Dutch Digitalisation Strategy 2.0:

- Innovation among teachers, school heads and administrators by learning together and with other parties for example by effective use of adaptive learning resources which meet pupils' learning needs and style of learning open innovation climate, cooperation between education and businesses
- Digitally literate pupils and teachers curriculum
- Digital teaching materials that work for users collaborating school boards in educational resources market (joint purchase) open-access educational resources

- Secure, reliable and future-proof infrastructure
- Ongoing consideration of ethical issues relating to the use of digital technology in education (Ministry of Education, Culture and Science, 2019; van der Vlies, 2020)

The digitalisation agenda for primary and secondary education is an initiative of: the Ministry of Education, Culture and Science; the Ministry of Economic Affairs and Climate Policy; the Primary Education Council; the Secondary Education Council; and Kennisnet. The Dutch Digitalisation Strategy 2.0 is an initiative of the Ministry of Economic Affairs and Climate Policy (Ministry of Education, Culture and Science, 2019).

Priorities and timescales

The digitalisation agenda contains the key ambitions and activities for the use of digital technology in primary and secondary education. The agenda's ambition is to promote effective cooperation within the education sector and between the sector and other parties, including the business community. The agenda is intended to set the course of digitalisation in education in the coming years (Ministry of Education, Culture and Science, 2019).

The Dutch Digitalisation Strategy 2.0 is organised into four areas: digital skills for citizens, digital skills for the labour force, digital skills for ICT specialists and digital skills in education (Digital Skills and Jobs Platform, 2021). The strategy outlined several priorities for 2019-2021: (AI), data science for social issues and economic growth, digital inclusion and skills, digital government, digital connectivity, digital resilience.

Is there funding attached to strategies/initiatives and how is this devolved?

We have not been able to identify funding linked to the digitalisation agenda for primary and secondary schools. However, the strategic action plan for the Dutch Digitalisation Strategy 2.0 includes subsidies (25 million euros/ 21.16 million GBP a year until 2022) for improving the connection of senior/upper secondary vocational education with the labour market, for example via projects that offer training in a profession that has changed as a result of AI (van der Vlies, 2020) (van der Vlies, 2020).

Does the strategy provide a rationale for the level at which decision making to support the digital strategy and associated funding is delegated? (NB: this should also include relevant information on school/local autonomy in the country and the levers available to support strategy implementation)

Within the framework set by the central government, administration of Dutch schools is highly decentralised, with a high degree of school autonomy. The Ministry of Education, Culture and Science is responsible for the quality of the education system. It sets national education policy for primary and secondary education, including standards, examinations and funding mechanisms. Municipalities are responsible for certain areas of education policy in compulsory schools, including infrastructure. Municipal authorities monitor compliance with the Compulsory Education Act and collect information on students who drop out. They also aim to informally influence local school policies. Under certain policies, such as the Local Education Agenda, co-operation is mandated between municipalities and other levels of government (OECD, 2014)

While schools in the Netherlands have extensive freedoms, this is balanced by a strong Inspectorate of Education. In the Netherlands, the concept of earned autonomy has been developed as part of the implementation of the Dutch Educational Supervision Act in 2003. Within the inspection framework, the intensity and frequency of school inspection is driven by student outcomes and the quality of the school self-evaluation. Student outcomes should meet the national standards, and self-evaluation results should be valid and reliable and provide information about indicators included in the inspection framework (OECD, 2014).

Dutch schools are formally more autonomous than schools in any other country. In no other country are so many of the key decisions on education taken at school board level: over 90% compared to an OECD average of 34% (OECD 2018).

What evidence is there of approaches/initiatives instead of, or in addition to, a digital strategy?

Currently, of the use of digital technology in the schools' sector is guided by the digitalisation agenda for primary and secondary schools focusing on the five key themes, which are also included in the the Dutch Digitalisation Strategy 2.0 as mentioned in the 'summary and gaps' section.

Which bodies take decisions about spending in the delivery chain from government to individual schools and colleges?

A distinctive feature of the Dutch system is the institution of school boards. Many powers are vested in these boards, rather than directly in the schools that are governed by these boards, The boards oversee the implementation of legislation and regulations in the school and employ teachers and other staff. While in the past public schools were governed mostly by local government, governance has increasingly been passed to independent school boards (OECD, 2016; Stevenson et al., 2021). School boards receive almost all their governmental funding in block grants, with the freedom to decide over personnel matters, assessments, curriculum and the general internal organisation.

Consequently, school board’s decisions, spending and choices differ (Stevenson et al., 2021).

Overview of bodies taking decisions about technology choices

Historically, public schools were run by local authorities, while private schools were governed by school boards consisting of local dignitaries and parents. Both the local councils and the private boards oversaw the schools they ran, but left the day-to-day decision making at the school level. Local councils could oversee multiple schools; private boards tended to oversee only one school. Over the last two decades however, a major shift in governance has taken place. National policy promoted that non-professional school boards governing one school be merged into professional school boards governing a number of schools. These professional school boards were no longer expected to only oversee the schools they govern, but were now explicitly expected to take the responsibility for day-to-day decision making. In 2009, school boards were additionally made formally accountable for the organisational and educational quality of the schools they govern. As a consequence of these policy shifts, a rapid development towards more multiple school boards has taken place. In the private sector, this involved single school private boards merging with other private boards in foundations, governed by one board overseeing multiple schools. In the public sector local authorities overseeing public schools created independent boards to oversee the different schools previously governed by the local council (Stevenson et al., 2021).

School boards have legal authority over one or many schools . Boards are responsible for organisation of schools, including management of personnel and resources, organisation of instruction, and school self-evaluation and quality monitoring. School boards can be composed of volunteers such as parents, and/or of professional managers, and their composition varies widely across the Netherlands. School leadership can be shared among various officials in larger schools and, in secondary education, teachers are involved in school management. In the annual report on the state of education in the Netherlands, the Dutch Inspectorate reports that the number of ineffective school boards has decreased, but there is still a need to strengthen the capacity of school boards to govern effectively (OECD, 2014)

The characteristics of the Dutch education system enable a large variation among school boards regarding size, governance, and educational leadership. The school governors who make up the boards may be voluntary (laypersons receiving an honorarium) or salaried professionals. Some school boards have gaps in their capacity to manage performance and finances and to develop a strategic improvement culture (OECD, 2016). According to OECD (2016), accountability and democratic control of school boards are both relatively weak (OECD, 2016).

Specific decision areas (centralised or devolved) and links to strategies and funding

Broadband connectivity

See digital infrastructure.

Digital infrastructure (including Wi-Fi, switching and cabling, servers and cloud storage and internal networking in school/college buildings)

A key priority has been IT infrastructure via funding opportunities or joint purchasing of ICT equipment.

The following activity is highlighted in the Digitalisation Agenda for Primary and Secondary Education:

School boards collaborate on a secure, reliable and future-proof infrastructure

SIVON (the cooperative of and for school boards in primary and secondary education) was established to centralise the necessary expertise and bring about a favourable price-quality ratio for education. It is a cooperative association of school boards in primary and secondary education. By concentrating its members' wishes into centralised demands, SIVON can give schools access to high-quality facilities – more specifically IT facilities – under favourable conditions. School boards that have yet to make a decision on installing sufficiently fast internet can make use the future-proof internet regulation for primary and secondary education (Ministry of Education, Culture and Science, 2019).

Data (interoperability, security)

In 2018, the primary education sector, supported by the government, drew up a privacy covenant in which they agreed on how to handle students' personal data generated and exchanged through digital learning materials and tests in accordance with the General Data Protection Regulation (GDPR). For instance, the covenant led to agreed-upon rules about the use of pseudonyms to guarantee student privacy in aggregated data, and about data minimisation—the requirement to reduce the number of data attributes in data flows between platforms. The covenant has subsequently been translated into a technical standard, called ECK-iD: a unique and encrypted identification mechanism for students using digital learning materials. An ECK-iD warrants the authentication of users logging into Basispoort, facilitating the exchange of learning data and results between various networked digital learning platforms and online management systems, while protecting a student's identity for data mining. ECK-iD allows primary schools to control data flows, because they have jointly defined a minimal set of data attributes recorded in an 'attributes policy' (Kerssens and Dijck, 2021).

The following activities are highlighted in the Digitalisation Agenda for Primary and Secondary Education:

Tools to help school boards and schools engage in the ethical discussion

In the form of tools and guidelines, schools are given support in conducting discussions about educational values in relation to the use of digital technology. This conversation takes place both within the school and between the school and developers of digital products and services. This will result in a clear focus on the values of education in the design of new products and services (Ministry of Education, Culture and Science, 2019).

Back-office systems (the software that supports the technology)

The following activity ais highlighted in the Digitalisation Agenda for Primary and Secondary Education:

Developing a long-term data strategy for new, innovative applications

Data on learning is a vital raw material for developing new, innovative applications that further the aims of education. To provide guidance and scope for opportunities, a long-term data strategy is being developed, covering aspects such as data ownership, transparency and safety for schools, parents and pupils (Ministry of Education, Culture and Science, 2019)

Accessibility (for example, audio visual)

No information found.

Hardware (for example, laptops, desktops, tablets, peripherals)

With an estimated market share of seventy percent, Google has become the largest supplier in Dutch primary education. Their market share grew by thirty percent each year between 2016 and 2019, with 170,000 Chromebooks purchased for primary and secondary education in 2018 alone (Kerssens and Dijk, 2021).

Software (for example, Management information systems, HR, finance, safeguarding, monitoring and filtering)

The following activities are highlighted in the Digitalisation Agenda for Primary and Secondary Education:

Developing public-private partnerships that put the user first

Publishers, distributors and software providers will work with the education sector in a public-private partnership to build a vision of the educational resources chain in 2023. This vision will centre on the education sector as a user; the educational resources chain will facilitate teachers in their work. The aim of the public-private partnership is to achieve this ambition (Ministry of Education, Culture and Science, 2019).

School boards collaborating in the educational resources market

School boards, united in the SIVON cooperative, are jointly committed to achieving a better match between supply and demand on the educational resources market. Success in this area will enable them to share tender documents, explore the market together and make joint purchases (Ministry of Education, Culture and Science, 2019).

Understanding developments on the supply side of the educational resources market

An open and accessible educational resources market is key to ensuring healthy market forces. The market is in flux: internationalisation and new entrants are changing the dynamic. These developments will be mapped and monitored with a view to gaining a better understanding of the forces at work (Ministry of Education, Culture and Science, 2019).

Making open-access educational resources available, usable and relevant

A great deal of open-access learning material is being developed inside and outside the education sector. However, this material is often not used to full effect. It is important to improve coordination between supply and the demand from schools, so that supply will have a lasting impact on education (Ministry of Education, Culture and Science, 2019).

Curriculum and business administration choices

The Netherlands has updated the curriculum to increase digital literacy in primary and secondary Education.

The Netherlands has made open-access of educational resources a priority. While a great deal of open-access learning material is being developed in and outside the education sector, this material is often not used to its full effect, according to the Digitalisation Strategy 2.0: The Netherlands contribute to public-private partnerships with publishers, distributors, and software providers to build a vision of the educational resources chain. This vision must centre on the education sector as a user, which should be put first in the partnerships. The Netherlands support SIVON, a cooperation between school boards that are jointly committed to achieving a better match between supply and demand on the educational resources market (Ministry of Education, Culture and Science of the Netherlands, 2019).

The following activity is highlighted in the Digitalisation Agenda for Primary and Secondary Education:

Digital literacy of pupils becomes part of the curriculum

Digital literacy will become part of the formal curriculum for primary and secondary education. Gaining practical experience of the new curriculum in its intended form will be part of this update. This will provide insight into the support required, stimulate curriculum development in schools and fuel the impact beyond the individual school, for example in the form of school curricula and teaching materials (Ministry of Education, Culture and Science, 2019).

Staff training

The following activities are highlighted in the Digitalisation Agenda for Primary and Secondary Education:

The education sector and the business community work together to produce digitally literate teachers

The education sector and the business community will reach agreements at sector and industry level on how to make teachers more digitally literate. The initiatives that result from this will serve to reinforce the curriculum update (Ministry of Education, Culture and Science, 2019).

Supporting teachers, school principals and administrators with innovation questions

Teachers, school principals and administrators receive support through various programmes to address their own innovation questions (Ministry of Education, Culture and Science, 2019).

Stimulating collaboration and knowledge sharing between schools and education professionals

Education professionals are being encouraged to share their knowledge and exchange insights with each other. This process involves launching a broad dialogue on the use of technology in education between administrators, school principals, teachers and policy makers (Ministry of Education, Culture and Science, 2019).

Technical support

No further information found.

Cyber security

The Hague region has established itself as a cybersecurity hub over the past decade. The Dutch government recently established the Global Forum for Cyber Expertise in The Hague, which is already home to Europol's European Cyber Crime Center (EC3) and the NATO Communications and Information (NCI) Agency. It is also home to The Hague Security Delta, the largest security cluster in Europe, in which (cyber) security businesses, government agencies, and knowledge institutions cooperate. The Netherlands is becoming a European leader in FinTech, AgTech, and technology-based mobility solutions, boasting a sizable cluster of startups (United States International Trade Administration, 2021).

In 2018, the National Cyber Security Center (NCSC) published an update to the 2013 "National Cyber Security Strategy." Both documents outline the government's long-term view on cybersecurity and set out concrete actions to combat cyber threats (United States International Trade Administration, 2021).

The following activity concerning cyber security is highlighted in the Digitalisation Agenda for Primary and Secondary Education:

Protecting pupil privacy to the full

When data is exchanged and used for a range of purposes, we ensure that pupil privacy is protected. This involves school boards and schools making sound agreements with providers on this matter (Ministry of Education, Culture and Science, 2019).

Other activities highlighted in the Digitization Agenda for Primary and Secondary Education:

Stimulating cooperation between education and business

The education sector and the business community work together to achieve the ambitions of this agenda, thereby stimulating and accelerating the process of innovation. Unnecessary obstacles will be removed by updating the sponsor covenant for primary and secondary education (Ministry of Education, Culture and Science, 2019).

A public dialogue on the ethical aspects of digitalisation in education

“To encourage thinking about the ethical aspects of digitization, we are facilitating a public dialogue on this issue. A group of scientists and progressive thinkers will be invited to fuel this exchange of ideas with relevant recommendations” (Ministry of Education, Culture and Science, 2019).

How (and by how much) infrastructure is funded, and how this investment is supported and delivered

The Netherlands is marketed as the digital gateway to Europe and is considered one of the most wired countries in the world. The country has consistently ranked first in the annual DHL Global Connectedness Index (United States International Trade Administration (2021).

All households in the Netherlands should have the opportunity to access broadband networks of at least 100 Mbps and a vast majority should be taking advantage of 1 Gbps by 2023 (European Commission. Broadband in the Netherlands).

The Dutch broadband strategy opts for a market-based infrastructure roll-out. It also puts key emphasis on the role of local and regional actors in coordinating and simplifying the process. Most of the broadband infrastructure roll-out is done by private operators autonomously. Here, removing barriers and facilitating the exchange of information and best practices among stakeholders are the principal tasks of local governments to stimulate investment by operators (European Commission. Broadband in the Netherlands).

Various efforts have been made to coordinate between local and national governments regarding permit granting procedures. Next to information and knowledge sharing, the Ministry of Economic Affairs and Climate Policy created a taskforce of national and local authorities to develop a uniform approach to permit-granting procedures for antennas and access to physical infrastructure for small cells. The government also introduced the possibility of establishing broadband coordinators and developing guidelines on fees (European Commission. Broadband in the Netherlands).

Although there are no state aid measures foreseen on a national level, a number of regional authorities are investigating the possibilities of state aid measures. The national government supports these authorities and is working on a framework for state aid. There is an umbrella scheme currently under development, which will make it easier for local authorities to provide financial support for construction (European Commission. Broadband in the Netherlands).

Evidence of the cost effectiveness of different models

We have been unable to locate any information regarding the implications and effectiveness of either the agenda or the strategy introduced in 2019.

Norway

Summary and gaps

Norway has a highly decentralised education system designed purposely to allow decisions to me made at a local level to reflect local contexts and priorities. Most funding decisions are devolved, with the state consequently having few levers at its disposal to ensure compliance with national priorities. Although there is a digital strategy, and accompanying action plan, there is little central funding attached. National government exerts a degree of influence through national curricula (although these are interpreted locally) and initial teacher training and development (although participation in teacher development is not mandatory). The government, through its agencies, has taken some limited steps in producing central resource libraries and portals, although use of these is not mandatory. Although the digital strategy cites infrastructure as a challenge, along with pupils' and teachers' digital skills, the former is not addressed in the accompanying action plan, perhaps because infrastructure is devolved and the government lacks mechanisms to influence. Consequently, the focus is on strengthening the curriculum and teacher training.

Because of the devolved system for funding and decision making, information on spending on the use of digital technology in education is largely lacking in the literature. Equally, the lack of system-level spending means that evaluations of cost-effectiveness are also absent.

Overview of school system

Norwegian children start school during the year of their sixth birthday. Compulsory education (Grunnskolen) covers 10 years and comprises two stages: primary school (grades 1-7) and lower secondary school (grades 8-10). No formal division is made between the stages. Some schools cover all compulsory education, while others are purely primary schools or lower secondary schools.

Upper secondary education (videregående opplæring) is not mandatory, but young people who have completed primary and lower secondary education, or the equivalent, have a right to up to four years of upper secondary education and training. Vocational education and training usually consists of two years in school and one-year in-service training (Eurydice website (ud); Eurydice 2022a).

The administration of the education system is divided into three levels; central level, county level, and municipal level with different responsibilities:

- The Ministry of Education and Research has the overall responsibility for policy and research in education of all stages, and for institutions of higher education
- The counties are responsible for upper secondary education, including school management and administration, the intake of pupils and the appointment of teachers
- The municipalities are responsible for kindergartens, primary and lower secondary education, including school management and administration, the intake of pupils and the appointment of teachers. (Eurydice 2021a)

Funding

The Norwegian national assembly has adopted a decentralised administrative structure which delegate considerable authority and financial freedom of action to the county level. The municipalities and counties draw most of their revenue from local taxes, and from a redistributive grant system. This system accounts for differences in their size, school-aged population, and disadvantage factors such as parental education and immigration background. While counties and municipalities have a high degree of autonomy in managing their resources, a number of regulations and agreements place limits on spending and revenues. For example, salaries and working conditions are negotiated centrally with social partners. All state institutions are expected to use a system of planning that covers both the short term (the budget year) and the medium term (3–4 years or more). State institutions must also formulate their objectives through a dialogue with the responsible ministry and establish a system for following up their results (Eurydice 2021a; OECD, 2020a).

Brief description of digital strategy

The Ministry of Education has published a digitalisation strategy for primary, secondary and vocational education for 2017-2021. This strategy has two goals:

- Pupils shall develop the digital skills they need to participate in society and to succeed in private life, education and work; and
- Schools shall effectively use the possibilities offered by digital technology and resources to enhance pupils' learning outcomes (European Schoolnet, 2018).

Priorities and timescales

According to Høydal and Haldar (2021), Norway, in 2006, was the first country to implement digital competence as a basic skill in its national curriculum and, in 2019, 83%

of Norwegian students had been provided with their own PC/laptop by their school by the ninth grade. Despite this, the Norwegian Government has published a number of interlinked strategies and plans intended to promote an enhanced digital agenda in Norway. These include overarching strategies, such as the white paper Digital Agenda for Norway and more specific documents such as the revised national curricula. Unfortunately, primary sources (for example government websites or official submissions to Eurydice) do not provide summaries of these publications, so information on their content is drawn primarily from secondary sources.

The digital strategy for education is entitled Future, Renewal and Digitalization: Digitalization strategy for primary and secondary education 2017–2021. Its first part sets out a vision of the future education system and the second the areas where action is needed to realise that vision. The goals are to provide students with ‘digital skills that enable them to experience life and succeed in further education, work, and community participation’ and that ‘ICT should be well utilized in the organization and implementation of training to increase student learning outcomes’. Areas for improvement actions include: student learning, the overall school curriculum, the competence of teachers and school leaders, the infrastructure of the education system, and vocational training (Høydal and Haldar, 2021).

The main challenges to the increased use of digital technology in schools are defined by the strategy as: a) students’ lack of digital skills, b) teachers’ lack of professional digital competence, c) the lack of adequate quality in digital learning resources, d) the lack of infrastructure, and e) the lack of research and evidence concerning the use of digital technology. (Høydal and Haldar, 2021).

In addition to the strategy, in 2020 the Norwegian Ministry of Education and Research published an Action Plan for Digitalisation in the Primary and Secondary Education and Training. This, and the accompanying ministerial press release, has been partially translated and described by Lund (2021) who states that the plan is primarily addressed to municipalities, rather than to schools or teachers. In particular, it aims to respond to challenges raised by municipalities. The plan also notes as a challenge that 36% of schools have no plans for systematic digital competence development, and only 20% report that pedagogic use of ICT is visibly integrated in annual plans and local curricula.

The foreword to the plan notes a renewed emphasis on the use of digital technology arising from school closures due to the pandemic and referencing implementation of the new curriculum. The plan itself has six themes:

1. An introduction focusing on roles and responsibilities, which emphasises the decentralised approach and the responsibility of municipalities and school owners for digital competence in teachers and the requirements and specifications relating to suppliers of digital administrative and educational resources.

2. Cooperation on access to digital learning resources. This covers the standardisation of services and access points, such as a service catalogue of digital learning resources with developing and piloting a portal which categorises resources to enable easy selection by teachers. There is also an intention to make the online catalogue or portal stimulate competition among providers of digital resources.
3. Data protection and privacy issues, with the objective of establishing an expert group to investigate pedagogical, legal, technological, and ethical issues in order to build a solid foundation for policymaking.
4. Teachers', learners', and school owners' digital competence with three contexts in which digital competence can be fostered: continuing education, education to become "teacher specialists," and local competence development. One action relates to ensuring in-service training and continuing education for teachers is relevant and adapted to technology-rich learning environments. Another action covers developing a guide for assessing the quality of learning resources and technology.
5. The knowledge basis for the use of digital technology in schools sets out the need for substantial research projects to improve understanding of how technology impacts on teachers' practices and students' learning and improves communication processes. It also sets out a number of additional action steps, such as establishing a roundtable conference for researchers investigating the use of digital technology in schools. The aim is to strengthen and support a thematic network, sustain discussions, and contribute to joint conceptual understanding.
6. The road ahead links the action plan to the digital strategy for schools and anticipates a new, revised strategy for 2022 (we have found no reference to this in the Anglophone literature, so it may be delayed).

The strategy underlines that digital competence does not only entail learning how to use digital tools, but must include elements like critical thinking, technological understanding, basic skills and social skills (European Schoolnet, 2018).

Is there funding attached to strategies/initiatives and how is this devolved?

The issue of funding outside of the standard school budget delegation seems to have had a complicated history in Norway, with the current situation of more or less complete delegation to local level making it difficult for central government to achieve priorities (OECD, 2022a).

Zounek et al. (2018) provides a history of the use of digital technology in schools in Norway in which the authors say that, from the 1980s onwards, central funding for ICT, largely to support the purchase of computers, was available. As the country moved towards a process of 5-year action plans for digitalisation in the 1990s, the Ministry of Education and Research announced a “normalisation of situation” regarding ICT in education. This meant that schools were no longer able to get any money dedicated specifically to ICT implementation and development as had previously been common, and this was therefore to be financed according to the ordinary arrangements at the different administrative levels. As a consequence, ICT started competing with other budget items and priorities. While the government continued to set priorities, schools “openly criticised the change regarding the allocation of funds and demanded bigger budgets to innovate and spread experience and knowledge in favour of integrating modern technologies into the educational environment successfully and meet the goals of educational policies” (Zounek et al., 2018).

However, there can sometimes be funding for specific initiatives. The teacher specialist project allows school owners to apply for a grant to appoint a number of teachers to the function as a specialist with an additional payment on top of their basic wages. The government and the Norwegian Association of Local and Regional Authorities (school owners) cover respectively 2/3 and 1/3 of the costs. Since 2016 the government has also provided relevant specialist education programmes for teachers corresponding to most of the piloted specialisation subjects and subject areas (Eurydice, 2022c). We have not found a figure for funding to date and, of course, teacher specialists are not restricted to those with a focus on ICT.

Similarly, there is some funding for developing the new competence model for continuous professional development in schools; again, this is not restricted to digital competence. The central funding for the decentralised model for professional development in schools in 2019 is approx. NOK (Norwegian Krone) 230 million (19 million GBP), while participating municipalities are required to add 30% of the funding. The new competence model aims at being fully implemented in 2020 (it is not known if this ambition has been realised), and the funding will eventually be at a level between NOK 300 and 400 million (25 – 33 million GBP) (Eurydice, 2022a). Municipalities are encouraged to collaborate in order to determine priorities and to decide how funds will be used (OECD, 2020a). However, OECD (2020b) noted that “this co-funding mechanism may limit the participation of the smallest and/or the least privileged municipalities”.

In 2017, the Ministry of Education committed NOK 90 million (7.5 million GBP) for the use of digital technology in teacher education. By 2018, five teacher education institutions (out of 20) had applied and received funding for their projects, which will run for three years. The aim is to ensure that student teachers develop the professional digital competence that they need. The institutions are required to share the results of their projects on a national level (European Schoolnet, 2018).

Does the strategy provide a rationale for the level at which decision making to support the digital strategy and associated funding is delegated?

(NB: this should also include relevant information on school/local autonomy in the country and the levers available to support strategy implementation)

Although we can find no evidence in the Anglophone literature of the strategy providing a rationale for decision making levels (NB a full English translation is not available), the governance and funding of Norway's education system reflect a long-established tradition of decentralisation. In 2017, 29% of education decisions were taken at the local level, compared to an OECD average of 13% (OECD, 2022a). The OECD (2022a) also note that, while this approach has advantages in terms of promoting local engagement, "Norway has experienced challenges in ensuring effective and consistent implementation of education reforms at different levels of the system, with enough capacity at local levels."

The administration of the Norwegian education system takes place at three levels: the central level, the county level, and the municipal level. The municipality/county administration influences the extent of self-governance in schools/institutions in the municipality/county. The recent local government reform (effective January 2020) reduced the number of municipalities from 428 to 356, and the number of counties from 19 to 11 (OECD, 2022a, Eurydice, 2021a).

Central level

The Norwegian Parliament (Storting) and government set the goals and framework for the education system from early childhood education and care to higher education. The Ministry of Education and Research steers national education policy at all levels through legislation, regulations, curricula and framework plans. The Norwegian Directorate for Education and Training has national responsibility for supervising the quality and governance of early childhood education and care (ECEC) and schools. It ensures the implementation of national education policy and regulations at different levels of the system. It also has operational responsibility for curriculum development and national statistics for ECEC and school education.

County level

Norway's counties are responsible for upper secondary schools. The County Governors' Offices liaise between central education authorities and the municipalities and counties. They supervise the implementation of national policy at the regional level, handle complaints and appeals, and play a role in school inspections.

Municipal level

Public ECEC centres, primary, and lower secondary schools are owned and run by municipalities who are responsible for the running of the schools, the building and maintenance of school buildings, the intake of pupils and the appointment of teachers. In primary and secondary education, responsibilities for budgets, staffing, pedagogical planning and student admissions are often devolved to the school level (OECD, 2022a; Eurydice, 2021a).

While the extent to which decision making is devolved to schools varies, the head-teacher is responsible for both the administrative and pedagogical aspects of running the school and the school budget. School Boards, with representatives of parents, pupils, teaching personnel, other personnel and local municipal authorities, also influence school decisions (Eurydice, 2021a).

What evidence is there of approaches/initiatives instead of, or in addition to, a digital strategy?

New national curriculum

The national curriculum is set centrally. For each subject, learning goals and the annual number of lessons are defined but with scope for local adaptation. A school curriculum is adapted from the national curriculum and based on local authority priorities with, typically, detailed descriptions of learning goals, methods, teaching materials and evaluation. ICT is implemented in the curriculum as one of five basic skills: oral, reading, writing, numeracy and digital skills. A framework describes how these basic skills function at different levels, covering compulsory and secondary education. The framework divides the digital skills into four sub-categories: 1) searching and processing, 2) producing, 3) communicating, 4) digital judgment. Basic skills are cross-cutting – that is they are part of all subjects, rather than subjects in their own right – with related targets in each subject. In the national curriculum, the use of different digital tools – such as word processing and spreadsheet and presentation programmes – are, together with the use of the internet, the most frequently mentioned targets (European Schoolnet, 2018).

Knowledge Promotion 2020, the new curriculum for primary and secondary school, began implementation in 2020/21. Initial drafts were prepared by the Directorate of Education and Training in consultation with teachers and other education professionals and followed by an open consultation (OECD, 2020a). Digital skills remain one of the five basic skills but the reforms aim to form better links with subject curricula. In the revised curriculum, digital skills, programming and technology have been strengthened (Eurydice, 2022c; European Schoolnet, 2018).

Teacher specialists

The government has, since 2015, piloted a teacher specialist project with different types of teacher specialist (11 subjects and subject areas) which aims to recruit and retain the best teachers in the classroom and to strengthen schools as learning communities. The project started out on a small scale with 205 specialists and was at first intended to last for two years but has been expanded following a positive evaluation. The government's aim is to recruit 3000 specialists by the end of the pilot in 2022. The government has also provided relevant education programmes for specialist teachers for the piloted subject areas. Arrangements after the pilot will be informed by the outcomes of an evaluation programme and discussions with stakeholders (Eurydice, 2022c). The digital strategy cites specialist teachers as a mechanism for improving the use of technology in schools.

Professional Digital Competence Framework for Teachers

This framework emphasises the need for increased professional digital competence for teachers to enable them to exploit the new working and learning methods offered by digital technology. It sets out a Professional Digital Competence Framework for Teachers that was developed by the Norwegian Centre for ICT in Education and launched in May 2017. Its main purpose is to establish a framework for describing teachers' professional digital competence that can be used by national, regional and local authorities, by teacher education institutions, and teacher educators, to inform teacher education programmes and professional development programmes. It sets out knowledge, skills and competencies under a number of headings (for example School in society; Ethics; Pedagogy; and Subject Didactics) and relates these to the basic skills in the school curriculum, showing how they interact (European Schoolnet, 2018; the Norwegian Centre for ICT in Education, 2017).

Competence Development Model

This was launched by the Directorate for Education and Training in 2017 and supports school-based capacity building through a local analysis of teachers' needs. The ministry supports a programme of grants/cover for teachers taking part in professional development (participation in professional development is not mandatory for teachers in Norway). The aim is for municipalities to take responsibility for the development of their schools by engaging in networked collaborations with universities at the local and regional level (OECD 2020b; European Schoolsnet, 2018). There are three inter-related schemes:

- A decentralised scheme: that will help to ensure that all municipalities (and eventually county authorities, as school owners) implement competence-raising measures, by channelling state funds to the municipalities and universities. The municipalities themselves define and prioritise what they need, within the framework of national goals, in co-operation with universities.

- A follow-up scheme: in which municipalities that report weak results in key education and training areas over time, are offered support and guidance.
- An innovation scheme: where schools and kindergartens, and universities engage in partnerships and develop projects to apply for national research grants. The scheme is intended to result in more research-based knowledge about the school and kindergarten system and strengthen evidence-based policy-making (OECD 2020b).

The courses offered through the programme are required to include topics related to teaching with digital technology (European Schoolnet, 2018).

Which bodies take decisions about spending in the delivery chain from government to individual schools and colleges?

The system in Norway is highly decentralised with budget devolved to county level (for upper secondary) and municipality level for primary and lower secondary. Beyond that, municipalities and counties devolve spending decisions to schools themselves to varying degrees.

There is very little outside the main funding system that is directly funded by government, and even where there is some central funding available (for example for professional development), it is often a requirement for local contributions to costs to be made, with participation a decision for school owners.

Overview of bodies taking decisions about technology choices

At the central level, the Norwegian Parliament (Storting) and government set the goals and framework for the education system from early childhood education and care to higher education.

The Ministry for Education and Research steers national education policy at all levels through legislation, regulations, curricula and framework plans. (OECD 2020a; OECD, 2020b; Zounek et al., 2018). Its executive body is the Norwegian Directorate for Education and Training. Its main tasks are to promote quality development, quality assessment, analysis and documentation in kindergartens, primary and secondary education and training, and take overall national responsibility for supervision of primary and secondary education and training (OECD, 2020b; Eurydice, 2021b).The Norwegian Centre for ICT in Education was established in 2010 to implement specific priorities relating to ICT through cooperation with relevant public and private institutions; participate in international projects in ICT in education; and offer a range of services and products (for example software for schools, support and training courses for teachers) (Zounek et al., 2018). From 1 January 2018, the Centre became part of the Directorate for Education and Training which assumed responsibility for digital development (European Schoolnet, 2018).

STATPED is a central agency which focuses on the use of digital technologies to support children with special educational needs. Statped assists local authorities in their work and provides special teaching services on both individual and system levels in areas where the local authorities lack sufficient competence. Statped is also responsible for providing digital learning materials for special needs education. (Zounek et al., 2018; European Schoolnet, 2018).

The County Governor is the state's representative at county level and is responsible for monitoring the decisions, objectives and guidelines set out by the Storting and government. In addition, the County Governor provides an important link between municipalities and central government authorities. The Directorate of Education and Training has the direct responsibility for the work of the County Governors in the field of education (Eurydice, 2021c).

Municipalities are the school owners for primary and lower secondary schools, while counties are in charge of upper secondary schools. They are responsible for providing schools with sufficient learning materials, including ICT infrastructure and access to digital learning resources. They are also responsible for teacher CPD, local strategies regarding in-service training and school improvement for ICT (European Schoolnet, 2018).

Specific decision areas (centralised or devolved) and links to strategies and funding

Broadband connectivity

We could find no direct evidence of broadband connectivity related to schools. It is also not mentioned as a priority in the digital strategy. We were unable to find any recent statistics.

Digital infrastructure (including Wi-Fi, switching and cabling, servers and cloud storage and internal networking in school/college buildings)

Infrastructure is the responsibility of the school owner (municipality for primary/lower secondary; county for upper secondary) and must be funded from the standard education funding stream since the mid 1990s. However, it remains a challenge according to the digital strategy, although there do not seem to be any planned initiatives to improve the situation within the associated action plan.

Data (interoperability, security)

The Norwegian architectural framework for interaction, published in June 2018, is intended to help enterprises to define, design, develop and manage digital services and the exchange of data with the public sector. The framework provides access to a common toolbox that contains principles, concept definitions, models and guidelines for digital interaction. It contributes to increased interoperability and interaction ability in the development of digital solutions (EC, 2019). We could find no information on how this might relate to schools specifically.

Back-office systems (the software that supports the technology)

Feide – joint electronic identity – is the preferred solution for secure identification in the education sector, chosen by the Norwegian Ministry of Education and Research. With Feide, students and staff have access to a wide variety of services related to research and education using just one username and password. Feide is available to all schools in the Norwegian primary and secondary education.

Accessibility (for example, audio visual)

Through the Statped agency, the government supports the development of learning resources for special educational needs which are available free of charge to schools. One of Statped's main tasks is to further develop and implement technology that can benefit users on an individual basis (European Schoolnet, 2018).

Hardware (for example, laptops, desktops, tablets, peripherals)

While central funding was provided in the 1980s and early 1990s to support schools' purchase of hardware, this is now a responsibility for school owners. In 2019 83% of Norwegian students had been provided with their own PC/laptop by their school by the ninth grade, making Norway a leading nation in computer density in an educational context (Høydal, and Haldar, 2021). It is not cited as a challenge or a priority in the digital strategy.

Software (for example, Management information systems, HR, finance, safeguarding, monitoring and filtering)

The Norwegian Directorate of Education and Training has developed a system for managing digital exams, consisting of a test administration system and a test execution system. The test administration system- used by teachers/graders and management/administrative personnel to handle the administrative side of exams – for example to register students, graders and other users, allocate exams, register results and generate reports. The system manages identities, access and data related to the exam. In addition, a test execution system allows students to log on to access exams. It also allows the school's administrative personnel to manage and monitor the exam procedure and to access students' completed assignments (European Schoolnet, 2018).

Curriculum and business administration choices

As part of its covid response to support online learning, the Directorate for Education and Training published a list of information and resources and all schools received free access to tools for online teaching (OECD, 2020a; Eurydice, 2021e).

The Feide platform hosts a number of third- party digital tools covering a wide range of subjects and ages; some are free but most seem to require schools to pay (at least for full functionality) (website accessed 29/1/2022).

Beginning with the school year 2016/17, a three-year pilot introducing programming as an optional subject was implemented in a number of secondary schools. However, by 2018, the government decided to introduce programming as a permanent elective subject from 2019, and to start trials of programming and modelling in upper secondary school as well, without waiting for completion of the pilot.

To support the schools, counties and municipalities in implementing digital skills as an integrated part of the curriculum, the Norwegian Centre for ICT in Education developed the digital resource "IKTplan". IKTplan provides links and resources covering the competence goals in the curriculum. By 2018, more than 300 of Norway's 426 municipalities had started to use IKTplan as part of their strategy (European Schoolnet, 2018).

For the upper secondary school level, 18 of the 19 county authorities (all except Oslo) have come together to establish a digital learning resource portal, the National Digital Learning Arena (NDLA). The counties fund the initiative by allocating a portion of the funds that they receive to provide students with free learning resources. Some resources are bought from publishers and commercial content providers. The remainder of the resources are developed by teachers and moderated by universities and university colleges. The content provided is freely available to all students and teachers. The NDLA aims at providing high quality digital learning resources in all upper secondary subjects.

The Norwegian Centre for ICT in Education has established 'ICT in Practice', a portal that encourages teachers to share resources and practices (European Schoolnet, 2018.)

Staff training

Future Classroom Lab (FCL) in initial teacher education provides national support for institutions who are building FCLs for their teacher students. In 2018, three teacher education institutions had set up their own labs, with others planned. While these are independent initiatives by higher education institutions, the Ministry of Education and

Research does provide financial support for digital developments in Teacher Education Institutions in the form of a Call launched in 2017 for a total of NOK 90 million (7.5 million GBP) for professional development over 3 years, which can be applied for to support such initiatives (European Schoolnet, 2018).

A Professional Digital Competence Framework for Teachers has been developed and is offered as a guidance for policy developers, teacher educators, teachers, student teachers and others to use as a reference. It does not contain a self- or peer assessment tool, but may be used as the basis for the development of such tools (European Schoolnet, 2018).

A free MOOC (massive open online course) for teachers' professional digital competence, with ECTS (European Credit Transfer System) credits, was launched at the start of the 2018-2019 school year with central government support (European Schoolnet, 2018).

Technical support

Local school authorities are responsible for creating local plans and strategies to support schools in the use of ICT. School leaders can also use the IKTPlan30 resource, developed by the Norwegian Centre for ICT in Education, to support them in designing an ICT strategy for their school (European Schoolnet, 2018). Technical support is a responsibility of the school owners (counties or municipalities) but we could find nothing in the literature on how this is done. Staffing, including support staff, is frequently delegated to school level.

Cyber security

We could find no evidence of this in the Anglophone literature.

How (and by how much) infrastructure is funded, and how this investment is supported and delivered

Norway is one of the most extensively digitalised countries in the world. Every year, the EU surveys Europe's digital performance status through the Digital Economy and Society Index, DESI. DESI 2020 shows that Norway is clearly improving in the areas of digital infrastructure (broadband and mobile network coverage), digital public services and digital skills. Norway tops the ranking, with the other Scandinavian countries. According to the survey, Norway's population has the highest rate of internet activity, and more than 90% make use of digital public services or contact government agencies online. Norway's score is particularly high when it comes to online public administration processes and digital services for business. Along with Denmark, Norway's access to mobile networks and broadband connectivity is the best in Europe. Since 2012, more than NOK 70 billion (5.9 billion GBP) has been invested in the digital infrastructure, and substantial resources have been expended to ensure that it is safe and well prepared to withstand the onslaught of harsh weather as well as cyberattacks.

By the end of 2020, Norway had reached the target of 90% of households being offered high-speed broadband of more than 100 Mbps. The new target is that 100% of households should have access to 100 Mbps by 2025. The Broadband Development Act came into force on 1 July 2020. This legislation is intended to make it simpler for developers to access existing infrastructure like utility poles and pipes, thereby reducing the complexity and cost of further developing broadband. The government expects that this will speed up the development of high-capacity networks and give Norwegian citizens more broadband at a lower cost

In 2019 the private network companies invested more than NOK 12 billion (1billion GBP) in mobile and broadband networks. The government contributes with subsidies for the development of broadband connectivity in areas where this is not profitable for commercial developers. Since 2014, more than NOK 1.5 billion (126 million GBP) has been allocated for this purpose. These funds are distributed so that those with the greatest unresolved requirements receive the most, with county councils being responsible for allocating the money. Additionally, there is government support for telecom safety and emergency preparedness (Norway, Ministry of Local Government and Regional Development website, accessed 25/02/2022).

Evidence of the cost effectiveness of different models

We could find no evidence of this in the Anglophone literature.

Sweden

Summary and gaps

Sweden has a highly decentralised system, with funding and decision making devolved to the local level. While the national government has developed a digital strategy for schools, it lacks many levers to ensure its ambitions are fully realised and has provided no central funding to support it. An associated Action Plan has been developed by the Association of Local Authorities and Regions but, again, this is not accompanied by funding. This plan makes suggestions for areas in which a degree of national coordination would be welcome, but it is not clear if and how this might be happening. Largely, the government relies on its overarching goals being translated into more local plans, along with its ability to set the broad curriculum and content of national tests.

Neither the strategy, nor the associated action plan, are available in English so we have had to rely on secondary literature to understand their content; this will be partial as authors will have selected those aspects of the document relevant to the particular focus of the publication. In addition, the lack of central initiatives and funding mean that aspects such as infrastructure and hardware are also a local responsibility and information on decision making and spending is therefore not available in the literature.

Overview of school system

In Sweden, children begin compulsory education in the year they turn six at the preschool class (fYesrskoleklass) (this only became compulsory in 2018). The compulsory school (grundskola) then begins at the age of seven and ends at the age of 16.

Sweden has a decentralised education system within an overall framework of goals and learning outcomes set by the government (Eurydice, ud). The administration of the Swedish education system is decentralised to municipal level and there is no regional administrative level for education. The municipalities are responsible for the organisation of practically all public education below university level (Eurydice 2021d).

Compulsory schools can be run either by municipalities or as grant-aided independent schools. Grant-aided independent schools are open to all and follow the same curricula as municipal schools do and are required to be approved by the Swedish Schools Inspectorate (Eurydice 2021a; Eurydice 2022a)

Schools vary in size due to the rural nature of much of Sweden - one-third of municipal schools and more than half of grant-aided independent schools have less than 100 pupils. This can lead to schools working with integrated age levels where children of different ages are taught together in the same class (Eurydice 2022a).

Although municipalities have the responsibility for compulsory schools, OECD (2017) reports on an OECD study that found that schools themselves take the largest share of decisions (47 %), followed by municipalities (35 %), with the state taking the remaining 18 % of decisions. According to the same study, local autonomy is not matched with adequate public accountability. There is also some lack of capacity and clarity on roles and responsibilities at the local level (OECD, 2017).

Funding

The education system in Sweden is funded through agreements with municipalities and independent education providers with some state funding paid as what is called 'the general state grant' to the 290 municipalities. The state grant equates to around 15 % of school funding. The majority of school funding comes from revenues from municipal taxes that are then allocated under different funding models depending on the municipality. School funding is also influenced by school choice, as funding is attached to students rather than schools, with pupils able to choose to attend school outside of their own municipality which has to pay. School meals, tools and equipment (which we assume includes digital devices) are also free to pupils (Eurydice 2021a; Eurydice 2021b; OECD, 2017).

Grant-aided independent schools are also funded by municipal grants from the pupils' home municipalities and by state grants and are not allowed to charge fees. Those that provide education equivalent to that provided in the preschool, the preschool classes, the compulsory school and the upper secondary school, and which have been approved by the Swedish Schools Inspectorate, are entitled to grants from their pupils' home municipalities. The amount of the grant – which is determined on the basis of the school's undertaking and the pupil's needs – is paid according to the same criteria the municipality applies when distributing resources to the schools within its own organisation (Eurydice, 2021a; Eurydice 2022a).

Brief description of digital strategy

The National Digitalisation Strategy for the School System (2017) has, as its main objective, the ambition of creating further opportunities for the use of technology, achieving a high level of digital competence (especially in the context of children, students, and younger people), and promoting the development of knowledge and equal opportunities and access to technology. Implementation is intended to be complete by 2022.

The strategy was followed up, in 2019, with an action plan developed by the Swedish Association of Local Authorities and Regions (SALAR) which recommended 18 different initiatives to support the strategy. While some of these would be for municipalities and schools to integrate into their own plans, others seem to require a degree of national coordination and it is not clear if and how this will be forthcoming.

Priorities and timescales

The current digital strategy needs to be seen in the context of a number of digitally-related initiatives in Sweden beginning in the 1960s. Initially these were mostly small-scale trials and projects, but from the early 1980s and onwards they increased in reach and ambition. The mid-1980s focused on computer science education, then, from the late 1980s to the early 1990s centred on computers as pedagogical tools followed by, in the latter part of the 1990s, large-scale investments made by the Swedish Knowledge and Competence Foundation in IT in schools, primarily through 27 so-called ‘lighthouse projects’.

In the early part of the millennium the IT in Schools (ITiS) programme focused on both technological investments and in-service training of teachers (in which all 289 municipalities in Sweden and about 60,000 teachers took part). This was followed by another state-financed initiative to provide further in-service training and competence to Swedish teachers.

Then, in 2014, the report ‘A digital agenda in human service - a bright future can be ours’ was published. This argued that the use of digital technology could increase innovation and quality and counter gender inequity: “In the digital agenda, in 2014, the focus continued to be on revised curricula and syllabi with a digital perspective, how to promote and include digitally based national exams in primary and secondary school, greater acceptance for remote teaching in primary and secondary school, additional professional development in digital competence for teachers, and professional development in digital competence for school leaders” (Fransson et al., 2018).

The National Digitalisation Strategy for the School System

This is seen as an integral part of the national digitalisation strategy and its main objective is to create further opportunities for the use of technology, achieve a high level of digital competence (especially in the context of children, students, and younger people), and promote the development of knowledge and equal opportunities and access to technology (EU, 2021a). In the introductory part of the strategy access to, and the use of, digital tools is said to vary depending on gender, socioeconomic circumstances, and other demographical variables thus underlining the need for a national strategy that provides opportunities for all children and students to develop their digital competence (Fransson et al., 2018).

The EU (2021a) provides a summary of the strategy which is built on three focus areas, each containing sub-goals:

1. Digital competence for everyone
    - All children and students must develop adequate digital skills:
    - Children and students in primary and secondary grades should be given the necessary conditions to be able to develop digital competence.
    - Preschool principals, school principals and managers must have the ability to strategically lead digital development at their organisations
    - Staff, who work with children and students, must have the competence to identify, choose and use digital tools in education.
2. Equal access and use
    - Children, students and staff must have good and equal access to digital tools and resources in order to improve education activities
    - Children, students and staff must have access to relevant digital tools that are based on their needs and tailored to their conditions.
    - There must be appropriate infrastructure as well as technical and pedagogical support.
    - The digital learning resources used in teaching must be appropriate and the possibilities of technology should be utilised effectively.
    - Employee teaching and administrative work should be available in a digital format to contribute to policy analysis and implementation.
3. Research and follow-up on the possibilities of the use of technology:
    - Research on the impact of the use of digital technology on teaching and learning should be enhanced and supported.
    - Follow-up of the work to increase the use of digital technology in the school system shall be carried out and support the development of future activities and initiatives.

An English version of the strategy is not available in full, but a number of secondary literature sources provide further details, albeit through the lens of academic research studies.

Gustafsson (2021) explores the digital competence aspect of the strategy, noting that the term was defined in line with the European Commission’s framework and thus set within four areas: (a) understanding how the use of digital technology affects society, (b) ability to use and understand digital tools and digital media, (c) taking a critical and responsible approach, and (d) ability to solve problems and transform ideas into action. Fransson et al. (2018) see a connection between digital competence and the objectives given in the curricula and syllabi in the aim of improving equality through ensuring that understanding and use of digital tools is enhanced in female pupils while noting that the meaning of 'adequate digital competence' varies considerably depending on role and context.

Mårell-Olsson and BergstrYesm (2018) focus on what digital competence means for school principals. According to the strategy, successful integration of information and communication technologies (ICT) in schools requires principals to have the digital skills necessary to lead and support their staff in digital development work. This also means that school leaders need to be able to identify and assess the relevance of new digital solutions and develop their use based on local conditions and the educational needs of their pupils so that the use of digital technology can contribute to improved knowledge outcomes and increased educational goal achievement.

The strategy, in the section on equal access and use, emphasises the need for appropriate infrastructure, hardware and broadband, and systems that have interoperability. Such infrastructure, which includes broadband capacity, networks and access to technical support, is said to be important to both learning and administrative solutions for schools (Fransson et al., 2018). Coordination and cooperation are said to be key to providing suitable technological infrastructure but it is not clear from the literature how the strategy envisions this happening – if it does so.

Almén (2021) noted that the second objective of the digitalization strategy - equal access to and usage of digital tools for all in the school system – is a prerequisite for the first objective of digital competence. This research study found that the second objective to be a more prominent focus for schools, perhaps because of the need for access to digital tools for competence to be achieved, but also perhaps because figures like computer per student ratios are more easily measured and compared, potentially important in Sweden's competitive schools' market, in which funding follows students. Moreover, interviews with teachers found a degree of continuing uncertainty about what the strategy was intended to achieve pedagogically, despite curriculum changes, which is problematic in a system in which pedagogical decisions are largely the preserve of individual teachers.

Interviews with pupils with special educational needs and disabilities found that, since the implementation of the strategy, when access to computers or tablets became ubiquitous in all lessons rather than restricted to those with special needs, they had lost a means of compensating for some of the difficulties they had in keeping up with classmates. On the other hand, being the only ones in the classroom with digital tools, which was the case before strategy implementation except for specific lessons held in computer rooms, was seen by some as stigmatising.

To be successful then, the success of the strategy relies on operational developments in infrastructure, teacher training, technical support, and pedagogical and curricular change. "As we have seen, the digitalization strategy resulted in curricular change. However, dimensions such as the infrastructure development, teacher training, and technical support are left to the individual schools' discretion" (Almén, 2021).

Digital strategy action plan

To support achievement of the objectives set in the digital strategy to be reached by 2022, the Swedish Government decided to produce a supportive operational policy: the national plan of action for the digitalisation of schools (#skolDigiplan). The purpose is to help and support municipal and independent school organisers to achieve the goals planned in the national strategy for school digitalisation. Responsibility for this was assigned to the Swedish Association of Local Authorities and Regions (SALAR) whose members operate more than 80 % of schools. However, that SALAR, which is independent of government, was given the responsibility of producing a national school policy instead of the National Education Agency, can be considered unique in Sweden's history (RISE, 2019; Gustafsson, 2021).

A group of 13 members were appointed, which included membership from the National Education Agency and an independent school, with experience in the digitalisation of schools or organisational development. They produced a 60-page document, presented to the government in March 2019, which included a status analysis, with descriptions of needs to fulfil the goal of the national strategy for the digitalisation of schools, the responsibilities and undertakings of the educational providers, and suggestions of 18 national initiatives. These initiatives emphasised clarity of responsibilities, support for local school actors, improvement in teacher and school leadership training programmes, in-service training for school staff, nationally coordinated work on standardisation, strategic use of educational data, and more and better use of research (Gustafsson, 2021).

However, there remains uncertainty about how the work will be led, funded and nationally coordinated as well as how interdependencies between initiatives will be managed, although the plan is intended to support municipalities and independent school providers to implement the strategy. In particular, there is a concern that teacher training providers have not been sufficiently engaged to support the acquisition of digital competence in teachers and that principals will be concerned to comply with the Education Act in terms of curriculum and syllabi, but may not go further in the absence of funded and coordinated support (RISE, 2019; Gustafsson, 2021).

Is there funding attached to strategies/initiatives and how is this devolved?

School budgeting in primary and secondary schools is completely decentralised to municipalities which decide how resources will be allocated between schools. The school then has the responsibility of allocating the resources in the best way to meet the needs of students. OECD (2017) notes that “there is no general model for resource allocation, municipalities may not always have the knowledge or capabilities to allocate funding effectively.” This model remains in place for the implementation of the digital strategy which does not come with any additional financial support.

Gustafsson (2021), in interviews with members of the group responsible for developing the action plan, found that respondents considered additional financial resources (for example, for digital infrastructure and educational software) were important to enable policy implementation by the target date of 2022. Within #skolDigiplan, national requirements for additional resources were implicitly suggested within several initiatives. It was also suggested by some members that the lack of financial support nationally might partly be why SALAR was tasked with producing #skolDigiplan rather than the National Education Agency, as a centrally produced plan would expect to be accompanied by resources. RISE (2019) argued that the government must conduct an impact assessment of the digitalisation strategy, including of the financial and organisational consequences for school organisers. We could find no evidence that this has been undertaken.

Does the strategy provide a rationale for the level at which decision making to support the digital strategy and associated funding is delegated? (NB: this should also include relevant information on school/local autonomy in the country and the levers available to support strategy implementation)

There is no funding associated with implementation of the digital strategy, nor its action plan. Rather, both funding and decision making related to it mirror that for other aspects of the education system.

The system, with responsibilities described at each level, is:

The Swedish parliament (Riksdagen) determines the laws and the government sets the regulations for schools. Swedish schools are goal/learning outcome directed and the government steers the education by establishing these through the Education Act. These goals/learning outcomes relate to curricula and course syllabi. Mandatory national subject exams are held in years 3, 6 and 9 of compulsory school to assess students' progress.

Within the framework set by the parliament and the government, each municipality establishes a local school plan (skolplan) describing the financing, organisation, development and assessment of the activities within each school. This local school plan should indicate how the municipality intends to fulfill the national goals for the school. The municipality is also the employer of school personnel and hence responsible for their professional development. the municipalities are also responsible for the follow up of and evaluation of their work. Municipalities are required to set up one or more committees to ensure that:

- Goals of the curricula are achieved and general regulations are followed
- Municipal funds are allocated for school activities
- Qualified teaching and non-teaching staff are recruited and that staff members are offered professional development
- Schools have appropriate facilities and resources.

The school administrator at each school is required to establish a local work plan (lokal arbetsplan) based on the national goals and the local school plan. The work plan should define issues that are not determined in the national regulations, i.e. course content, organisation and teaching methods. This should be done in consultation with the teachers and other staff. The local work plan should also describe, in concrete terms, how the school intends to organise its activities in order to reach the centrally defined goals.

The school head has the overall responsibility for ensuring that the national and municipal goals are shaped into concrete educational objectives.

The school, or in most cases the teacher, decides what teaching materials and method to use. There is no regulation on teaching methods or on which kind of pedagogical tools (books, computers etc.) to be used (Eurydice 2021a; Eurydice 2021e; Eurydice 2022a; Eurydice 2022b).

Beyond the overarching curriculum and the mandatory exams, the government therefore has very few levers available to it as far as the use of technology in schools is concerned. However, digital skills are an essential part of the Swedish national curriculum in compulsory and upper secondary schools, emphasised during the last revision from 2018 (EU 2021b).

Almén (2021) notes that to buy digital tools for students is a major financial investment for the individual school but the government made it clear from the outset that the digitalisation strategy would not include any extra governmental funding. As a consequence, funding had to be reallocated with a consequent negative impact on other resources and staffing levels as schools had to invest both in hardware, such as computers and tablets, and teachers' professional education.

What evidence is there of approaches/initiatives instead of, or in addition to, a digital strategy?

The Swedish National Agency for Education (Skolverket) has been tasked by the government to develop digital national tests in compulsory school and upper secondary school from 2017-2022. In January 2019 the agency published a list of the technical requirements that schools must have in place to fully implement digital national tests by 2022.

Examples of technical requirements that need to be in place:

- A stable internet connection that can handle sound and film material and allows all students in a school year or upper secondary course to do the tests.
- The school should have enough computers (portable or stationary) or tablets so that all students in a school year or upper secondary course can complete the tests simultaneously.
- Tablets should have a screen size of at least 9.6 inches.
- The computers and tablets should have a screen resolution of at least 1366 x 768.
- Headphones should be available for use in samples containing sound material.

The objective of the development of digital national tests is to increase pupils' digital skills as well as contribute to ensuring that the national tests and the assessment becomes more robust.

The development is carried out in steps until the national tests will be fully digital in 2022 (Eurydice 2022c).

We were unable to find any evidence of funding attached to this initiative so it is likely that municipalities will be expected to ensure that technical requirements are met through standard funding streams.

Which bodies take decisions about spending in the delivery chain from government to individual schools and colleges?

The system in Sweden is highly decentralised with municipalities responsible for the majority of schools (and for funding independent schools using the same formula as for their own schools). Municipalities fund 85 % of school costs from local taxes, with the remainder coming from grant aid. Schools are funded on the basis of pupil numbers and the system allows pupils and their parents/carers to attend schools outside their home municipality which has to compensate the municipality receiving the pupil.

Municipalities are responsible for ensuring that schools are adequately resourced and for facilities, including digital infrastructure, but schools themselves also make decisions according to their school plan.

Overview of bodies taking decisions about technology choices

Decisions about technology choices are highly localised. However, the following organisations may have a degree of influence on those choices.

The Ministry of Education and Research (Utbildningsdepartamentet) and the central authorities connected to it have the overall responsibility for the central administration of the Swedish educational system. The Ministry sets the framework for the education system including curriculum, syllabi and national tests. It also has overall responsibility for the Digital Strategy. It also sets national goals through the Education Act which must be translated into local plans.

The central administrative authorities work independently of the Ministries within a remit set by the government. They are allocated funds annually through the government budget appropriation document decided by parliament and must present an annual report of their activities to the responsible ministry. The following agencies and organisations, amongst others, come under the auspices of the Ministry of Education and Research (Utbildningsdepartementet):

- The Swedish National Agency for Education (Skolverket) is the largest central authority in the school area. It supports and evaluates the work of municipalities and schools, co-ordinates with the Ministry in setting the national goals and curriculum and publishes a set of educational statistics. It also allocates funds to universities and university colleges for research into the school system, for the training programme for school heads, for competence development of teachers and personnel within the school on topics such as reforms, as well as for awarding teaching scholarships for the competence development of individual teachers.
- The Swedish Schools Inspectorate (Skolinspektionen) authorises the establishment of new independent schools and also ensures that municipalities, organisers of independent schools and the schools themselves follow the centrally-set laws and regulations. The Schools Inspectorate conducts regular supervision of all schools.
- The National Agency for Special Needs Education and Schools (Specialpedagogiska skolmyndigheten), is the central authority responsible

for allocating public funds for special pedagogical issues. The institute creates and provides support to school organisers on special pedagogical issues related to disabilities (OECD, 2017; Eurydice 2021d).

According to the Education Act, Sweden's 290 municipalities are responsible for the public school's sector. The municipalities and the providers of independent schools are organised in two associations: the Swedish Association of Local Authorities and Regions, representing the municipalities, and the Swedish Association of Independent Schools, representing private school organisers. The former is responsible for the Digital Action Plan. These associations are in charge of implementing educational activities, organising and operating school services, allocating resources and ensuring that the national goals for education are met. The Swedish Local Government Act decrees that every municipality shall be governed by an elected body, the Municipal Assembly. This Municipal Assembly appoints an education committee to govern its public education system, and school leaders in municipal schools report to the education committee. (OECD, 2017).

Specific decision areas (centralised or devolved) and links to strategies and funding

Broadband connectivity

Sweden has set an ambitious policy goal in terms of broadband connectivity (98 % of households and firms should have access to 1 gigabit per second by 2025) (OECD, 2018). We could find no information specific to schools, but they would presumably benefit from this.

Digital infrastructure (including Wi-Fi, switching and cabling, servers and cloud storage and internal networking in school/college buildings)

The strategy makes references to the need for appropriate infrastructure, hardware and broadband, and systems that have interoperability. Coordination and cooperation are said to be of importance for providing technological infrastructure that ensures easy access to, and use of, digital learning resources. Infrastructure is said to be of importance not only for the use of learning resources, but also for administrative solutions for schools. Examples of appropriate infrastructures are given, such as access to wireless net, enough broadband capacity, and other relevant equipment and support (Fransson et al., 2018). It is assumed that it would be for the municipalities to work together to achieve these aims.

The Action Plan proposal points to the need to develop common standards and national support for public procurement and technical system evaluation (RISE, 2019). However, it is not clear from the literature if there are detailed proposals for who would lead on this or if it has been taken forward as yet.

Data (interoperability, security)

This is covered to some extent by the role of the new digitalisation agency, but no school-specific information has been found although this is mentioned in the strategy.

Back-office systems (the software that supports the technology)

No information was found.

Accessibility (for example, audio visual)

As part of its COVID-19 response, the Special Education Authority (SPSM) has gathered its digital offerings that can now be accessed through a single portal. Schools can also download a free publication on digital learning and opportunities with digital tools for children and students with disabilities (National Network for Media and Information Literacy website accessed 1/2/2022).

Hardware (for example, laptops, desktops, tablets, peripherals)

By 2015, 75 % of lower secondary school pupils had access to a computer of their own in school. Now it is normal practice that lower and upper secondary schools provide either laptop computers or tablets to their students (Almén, 2021). There is no evidence of any national funding for this.

Software (for example, Management information systems, HR, finance, safeguarding, monitoring and filtering)

No information was found.

Curriculum and business administration choices

Recent revisions to the curriculum strengthen digital skills, in addition, from 2017, programming was introduced to mathematics at all school levels (Almén, 2021).

Single sign-on solutions that make it possible to access all available digital learning resources on the school's network without additional logins as well as a better overview of available educational content and more flexible licensing solutions are in the Action Plan. This kind of work is underway in the Gothenburg region, but it must also be established at the national level (RISE, 2019).

Staff training

The Digital Strategy sets out the ambition for digital competence for leadership and teaching staff. The Action Plan emphasised the need for improvement in teacher and school leadership training programmes and in-service training for school staff. However, those developing training (University providers) were not involved in developing the action plan and it is not clear what levers are available to enhance training programmes. Nonetheless, those developing the Action Plan teachers' digital competence was not viewed as a major obstacle, and most thought that most practitioners were on track to fulfil the policy goals by 2022. Even so, the inequality of digital competence among teachers was still a concern among the members (Gustafsson 2021).

Technical support

No information found.

Cyber security

No information found.

How (and by how much) infrastructure is funded, and how this investment is supported and delivered

The 2015-2018 Digital First agenda of the Swedish Government has five core areas of work covering digital government efforts:

1. A national digital infrastructure
2. Digital maturity
3. Capacity for digital innovation
4. One agency for digital government
5. Legal reform for digital first

However, evidence collected by the OECD (2018) suggests that the agenda stands "more as a policy statement issued by the Ministry of Finance rather than a vision widely shared, owned and recognised, or even known, by public entities." This seems largely to be because the development process was not particularly open or inclusive. As with the Digital Strategy for schools, "the verticality of the Swedish public sector hinders coordinated policy implementation."

The government established a digitalisation agency in 2018 with the responsibility for coordinating and supporting the use of digital technology in the public sector with a budget of 102 million Swedish crowns (just over 8 million GBP) in the 2018 Budget Bill. According to the provisions of the bill, these funds should be used to cover the management expenses of the new agency, coordinate and support inter-agency digitalisation efforts to increase the use of technology, the national digital infrastructure and open data. As a result, the use and allocation of financial resources for the development of the digital infrastructure and open data is intended to increase control over high-risk and strategic ICT projects and to align all agencies efforts in updating the IT infrastructure for the public sector (OECD, 2018).

Sweden’s national broadband plan, adopted in 2016, has the vision of an entirely connected Sweden and has goals for both mobile coverage and for high-speed broadband connections for households and businesses. By 2020, 95 % of all households and companies should have access to broadband at a minimum capacity of 100 Mbps and by 2025, all of Sweden should have access to high-speed broadband. In its broadband strategy, A Completely Connected Sweden, the Swedish Government has identified three strategic areas in order to meet the goals set in the strategy: Roles and rules on the broadband market, cost-efficient expansion of the broadband infrastructure and services for everyone. According to the focal point has to be people’s need for broadband access, whether they live in densely populated areas, scarcely populated areas and rural areas, or in areas situated in between. The objective of the strategy is that 95 % of all households and businesses should have access to broadband at a minimum capacity of 100 Mbps by 2020 and by 2025 all of Sweden should have access to high-speed broadband. Sweden is also committed to be at the forefront of the development of 5G (European Commission, Broadband in Sweden, website accessed 25/02/2022).

State aid for broadband deployment in areas where there are no commercial investments in next generation access networks is available through the Agricultural Fund for Rural Development (EAFRD) and in the northern part of Sweden via the European Regional Development Fund (ERDF). SEK 202.8 million (16.1 million GBP) are provided to the Rural Development Programme for 2014–2020 for continued broadband expansion in rural areas.

Financed through the Recovery and Resilience Fund, the Government intends to invest SEK 1.4 billion in 2021 (111.2 million GBP), SEK 500 million (39.7 million GBP) in 2022 and thereafter SEK 100 million (8 million GBP) annually during 2023-2025 to expand broadband throughout the country and achieve the national broadband targets. The Swedish Post and Telecom Agency (PTS) is the managing authority for this support scheme. During the current programme period for the rural development programme (2014–2020), the Government has also allocated approximately SEK 4.45 billion (357.3 million GBP) in broadband support for expansion in areas where it is not commercially profitable to expand.

The Government has also made investments of SEK 1.2 billion (95 million GBP) within the regional fund for the expansion of larger local interconnection broadband networks in the three northern regional fund programs (European Commission, Broadband in Sweden, website accessed 25/02/2022).

Evidence of the cost effectiveness of different models

We could find no evaluations of cost effectiveness in the Anglophone literature. This is likely to be because spending is highly devolved to the local level with no centrally funded initiatives, making systematic evaluation challenging.

United States of America

Summary and gaps

Education is primarily the responsibility of state and local government. Every state has its own department of education and laws regulating finance, the hiring of school personnel, student attendance, and curriculum. In most states, the public education system is further divided into local school districts, which are managed by a school board representing the local community. Admission into public schools is usually automatic based on residency

The National Education Technology Plan (NETP) is the flagship educational technology policy document for the USA. The plan articulates a vision of equity, active use, and collaborative leadership to make everywhere, all-the-time learning possible. The plan, includes the following five components: Learning, teaching, leadership, assessment and infrastructure.

The NETP recommends school districts implement the plan through an unspecified mix of federal programs and reliance on non-profit organizations (Starks, 2021). However, the federal government does not systematically fund technology in schools and federal support is insufficient for schools to invest in and maintain a comprehensive technology programme. Moreover, states vary in terms of the funds they make available for technology in schools and, as of 2019, only 21 states had any kind of dedicated state funding for technology. Due to lack of federal and state funds for technology in schools, most states rely on local revenue sources to fund technology in K-12 public schools.

The NETP is updated every five years and the Office of Educational Technology is currently working to update and expand upon the vision for how schools and districts in the USA can use technology that was presented in the 2017.

Overview of school system

In most states, education is compulsory from five or six to sixteen; but in some states young people are required to stay on in school until age 18.

All children in the USA have access to free public schools. Private schools (religious and non-sectarian) are available, but students must pay tuition fees to attend them. The system is broken down into three stages:

- Elementary school (Grades K–5)
- Middle school (Grades 6–8)
- High school (Grades 9–12)

American educators frequently use the terms K-12 education to refer to all primary and secondary education, from kindergarten prior to the first year (or 1st grade) of formal schooling, through secondary graduation (12th Grade) Admission into public schools is usually automatic based on residency.

Funding

Although the federal government contributes almost 10% to the national education budget, education is primarily the responsibility of state and local government. It is states and communities, as well as public and private organisations of all kinds, that establish schools, develop curricula, and determine requirements for enrolment and graduation. The structure of educational finance in the USA reflects the predominantly state and local roles. The state governments gather and distribute a significant amount of funding for schools through state sales and income taxes, lotteries, and property taxes. Local governments also often contribute through their respective taxation systems (United States Department of Education website. The Federal Role in Education).

Brief description of digital strategy

First released in 1996 and updated every five years since, the NETP (2017) sets a national vision and plan. The plan articulates a vision of equity, active use, and collaborative leadership to make everywhere, all-the-time learning possible. While acknowledging the continuing need to provide greater equity of access to technology itself, the plan goes further to call upon all involved in American education to ensure equity of access to transformational learning experiences enabled by technology (Department of Education of the United States. 2017)

The Office of Educational Technology is currently working to update and expand upon the vision presented in the 2017 NETP to ensure its relevance and usefulness based on the policy, funding and social contexts within which digital learning now occurs. The revised NETP will incorporate new developments in education technology and share a vision for how schools and districts across the country can continue to use technology to improve equity and opportunity for all students. It will also address infrastructure needs in order for the vision to become a reality (Office of Educational Technology Website).

Priorities and timescales

The priorities of the 2017 NETP are as follows:

- Empower learning through technology: high-speed internet access, personalised learning, blended learning, building competencies:
    - focus on new technologies, for example virtual learning labs, use of games and simulations, new ways to connect physical and virtual interaction, AR

    - equity, closing digital use divide (accessible technology);
- Teaching with technology: teacher training, advancing educational technology in teacher preparation, ongoing professional learning;
- Leadership (creating culture and conditions for Innovation and change):
    - openly licensed educational resources
    - federal funds to support technology-based strategies to personalise learning;
- Assessment:
    - enable enhanced question types, measure complex competencies, provide real-time feedback, increase accessibility, adapt to learner ability and knowledge, embedded with learning process, assess for ongoing learning
    - continuous improvement of assessments, integrated learning and assessment systems, using data effectively and appropriately, learning dashboards that enable visualisations, set of shared skill standards;
- Infrastructure: ubiquitous connectivity, powerful learning devices, high-quality digital learning content, responsible use policies (van der Vlies, 2020; Department of Education of the United States, 2017).

Is there funding attached to strategies/initiatives and how is this devolved?

The federal government does not systematically fund technology in schools, however there is a mix of federal and state grant money available for technology-enabled learning. Funds are available through the Every Student Succeeds Act (ESSA), Individuals with Disabilities Education Act (IDEA), E-rate programme, and federal COVID relief funds like the CARES Act. However, schools are limited in how they can spend this money. According to Starks (2021), with these constraints in mind, federal support is insufficient for any school to meaningfully invest in and maintain a comprehensive technology programme.

States vary in terms of the funds they make available for K-12 technology. Only 21 states have any kind of dedicated state funding for technology (SETDA, 2019). Due to lack of federal and state funds for technology in schools, research evidence suggests that most states rely on local revenue sources to fund technology in K-12 public schools (SETDA, 2019).

The NETP recommends school districts make sure students have equitable access to technology through an unspecified mix of federal programs and reliance on non-profit organisations (Starks, 2021)

Does the strategy provide a rationale for the level at which decision making to support the digital strategy and associated funding is delegated? (NB: this should also include relevant information on school/local autonomy in the country and the levers available to support strategy implementation)

In the USA, state and local government are primarily responsible for education. Every state has its own department of education and laws regulating finance, the hiring of school personnel, student attendance, and curriculum. In most States, the public education system is further divided into local school districts, which are managed by a school board, representing the local community. School districts can be small, covering just a small town or rural county, or enormous, covering a whole large city.

According to their local policy, school districts are responsible for coordinating education policies, planning for changing educational needs in the community, and often establish programs and curricula. They also delegate a varying amount of freedom or independence to each individual school within their sector (with some exceptions, such as general rules concerning health and safety). There is considerable variation among schools regarding courses, subjects, and other activities depending on where the school is located. Public schools rely heavily on local property taxes to meet the vast majority of school expenses (Corsi-Bunke, (n.d.).

What evidence is there of approaches/initiatives instead of, or in addition to, a digital strategy?

Two substantial country-wide initiatives currently sit alongside the NETP. First, there is the Federal Communications Commission’s (FCC’s) Emergency Connectivity Fund (ECF), which is a $7.17 billion (5.44 billion GBP) programme designed to help schools and libraries provide the tools and services their communities need for remote learning during the COVID-19 emergency period. ECF provides support to millions of students, school staff, and library patrons and will help close the Homework Gap for students who currently lack necessary internet access or the devices they need to connect to classrooms (Office of Educational Technology Website).

Second, Congress recently created the Affordable Connectivity Program (ACP), a new long-term, $14 billion (10.62 billion GBP) programme, which will replace the Emergency Broadband Benefit Program. This investment in broadband affordability is designed to help ensure appropriate connections for work, school and health care (Office of Educational Technology Website).

Which bodies take decisions about spending in the delivery chain from government to individual schools and colleges?

States vary substantially in the funds they make available for K-12 technology. Only 21 states have any kind of dedicated state funding for technology, and this can range from just digital instructional materials (for example software and electronic textbooks, as is the case in New Mexico) to physical devices (for example laptops and tablets, as in Maine) according to a recent analysis from the State Educational Technology Directors Association (SETDA).

Several states have allocated funds or technology-specific grants to enhance internet access for K-12 students (including Utah, Washington and Maine), although some of these programs are still quite limited in terms of funding and resources. Due to lack of both federal and state funds for technology in schools, most states rely on local revenue sources to fund technology in K-12 public schools (SETDA, 2019).

Overview of bodies taking decisions about technology choices

Federal government has removed the requirement for school districts to prepare a three-year technology plan when applying for state funds for technology. However, some states recommend that districts continue with the practice of creating such a plan and provide guidance on requirements for a good technology plan. This is the case, for example, with the Oklahoma State Department of Education (2020) whose requirements include:

- Technology type and costs: a description of the type and costs of technology to be acquired with Ed Tech funds, including provisions for interoperability of components on a three-year basis.
- Coordination with other resources: a description of how the applicant school district will coordinate activities funded through the Ed Tech programme with technology-related activities supported with funds from other sources.

The NETP includes the following recommendation:

Develop funding models and plans for sustainable technology purchases and leverage openly licensed content while paying special attention to eliminating those resources and tasks that can be made obsolete by technology.

Rather than viewing technology as an add-on component to support learning, leaders should take stock of current systems and processes across learning systems and identify those that can be augmented or replaced by existing technologies. During the planning process, they also should identify systems and processes for which no replacement currently exists within the district, school, or college and set goals for developing more efficient solutions (Department of Education of the United States, 2017).

Specific decision areas (centralised or devolved) and links to strategies and funding

Broadband connectivity

The USA has placed the ICT infrastructure at the heart of its digital education strategy. Van der Vlies (2020) notes that the NETP requests leaders to take responsibility and ensure ubiquitous access among education stakeholders to connectivity and devices, as well as to support personnel to ensure equipment is well maintained. Leaders should recognise the importance of building capacity for creating and maintaining the technology infrastructure.

The NETP includes the following recommendation:

Ensure students and educators have broadband access to the internet and adequate wire- less connectivity, with a special focus on equity of access outside of school.

Although connectivity itself does not ensure transformational use of technology to enable learning, lack of connectivity almost certainly precludes it. Working with federal programs such as E-rate through the FCC, as well as with non-profit partners such as CoSN, Education Super Highway, EveryoneOn, and others, states, districts, and postsecondary institutions should make sure technology-enabled learning is available for all students, everywhere, all the time (Department of Education of the United States, 2017).

Digital infrastructure (including Wi-Fi, switching and cabling, servers and cloud storage and internal networking in school/college buildings)

The NTEP includes the following recommendations:

Ensure that every student and educator has at least one internet access device and appropriate software and resources for research, communication, multimedia content creation, and collaboration for use in and out of school.

Only when learners have the tools necessary to complete these activities are they able to realize the potential of education technologies fully. States and districts should make sure such device purchases are funded sustainably with a plan for device refresh (Department of Education of the United States, 2017).

Draft sustainability plans for infrastructure concerns that include upgrades of wired and wireless access as well as device refresh plans and sustainable funding sources while ensuring the safety and protection of student data.

As state and local education institutions work to bridge the existing digital divide, they concurrently should be drafting plans for the upgrade of infrastructure necessary to meet the needs of increased user demand as well as speeds necessary for the use of evolving technologies. These plans should include specific systems and strategies for protecting student data, be drafted with cross-stakeholder groups, and include special consideration of funding sustainability and possible partners (Department of Education of the United States, 2017).

Data (interoperability, security)

The Office of Educational Technology website highlights two initiatives:

- The Education Blockchain Action Network is a shared, community-driven, action-oriented space for conversation, community curation, and open-source project development. Educators, administrators, parents, students, and technology developers are invited to work collectively to learn, influence, and equitably shape the ways in which these new technologies affect our shared future.
- The Education Blockchain initiative, launched in partnership with the American Council on Education in February 2020, explores novel applications of distributed ledger technologies like blockchain to address complex challenges in education. This initiative focuses particular attention on understanding how blockchain technology can facilitate the secure, traceable, and verifiable exchange of educational data among institutions in the learning and employment ecosystem.

As part of the Education Blockchain Initiative, the Office of Educational Technology (OET) and the Privacy and Technical Assistance Center (PTAC) have developed a suite of materials concerning education blockchains.

The NETP includes the following recommendations:

Revise practices, policies, and regulations to ensure privacy and information protection while enabling a model of assessment that includes ongoing gathering and sharing of data for continuous improvement of learning and teaching.

This will require not only greater systems interoperability standards but also increased capacity on the part of educators and administrators to understand the types of systems they want to establish within schools and colleges. In addition, they will need to have an understanding of the standards of interoperability they should demand from vendors. A key component of this increased capacity should ensure educational leaders have a firm understanding of privacy and security concerns, how those concerns are addressed within the school or system, and clear communication of policies and procedures with all stakeholders. Achievement of this recommendation would benefit from the involvement and guidance of organisations, such as CoSN, ISTE, and the State Educational Technology Directors Association (SETDA), that have developed specialized expertise in these areas (Department of Education of the United States, 2017).

States, districts, and others should design, develop, and implement learning dashboards, response systems, and communication pathways that give students, educators, families, and other stakeholders timely and actionable feedback about student learning to improve achievement and instructional practices.

The next generation of such tools should integrate across platforms and tools seamlessly, be designed with a mobile-first mindset, and be guided by UD and UDL principles to ensure accessibility by all stakeholders. Although current products and dashboards include basic functionality and features that improve on those of their predecessors, future iterations should be built on a premise of feedback and conversation, allowing learners and families to discuss learning out- comes and evidence and increasing agency and ownership across stakeholder groups (Department of Education of the United States, 2017)

Create and validate an integrated system for designing and implementing valid, reliable, and cost-effective assessments of complex aspects of 21st-century expertise and competencies across academic disciplines.

Interoperable formative assessment formats offered by major testing consortia for use by educators throughout the year are an important first step. However, work remains to ensure more educators have access to high-quality formative assessment tools and to develop additional capacities to assess both cognitive and non-cognitive skills better. Moving forward, increasing educator capacity for the design and deployment of valid and reliable formative assessments will require the concerted efforts of current assessment developers, teacher preparation programs, school systems, and researchers. Furthermore, colleges and universities will benefit from system-wide reviews of assessment practices and from ensuring all faculty have deep understandings of key principles and practices surrounding the design and implementation of effective learning assessments (Department of Education of the United States, 2017).

Back-office systems (the software that supports the technology)

No information found.

Accessibility (for example, audio visual)

No information found.

Hardware (for example, laptops, desktops, tablets, peripherals)

The NETP states that selecting the appropriate devices depends in large measure on the age of students, their individual learning needs, and the types of learning activities that will be ongoing in the classroom or after school programmes. It also mentions an instructional burden for teachers, who have to manage learning activities while supporting multiple platforms and device types. Activities can also be incompatible with certain devices. Finally, there may be privacy and security issues with regard to the use of personal devices, as they might lack required safeguards (van der Vlies, 2020).

Software (for example, Management information systems, HR, finance, safeguarding, monitoring and filtering)

The NETP states that the use of openly licensed educational resources is one of the most effective ways to provide high-quality learning materials at scale. Open licenses should make the use of resources possible without paying any licensing fees or requesting permission. For learning resources, open licenses such as Creative Commons could be used, and for software, open licenses such as GNU General Public License, or other licenses recognised by the Open Source Initiative or the Free Software Foundation. The USA currently spends USD 8 billion (6.07 billion GBP) per year purchasing commercial learning resources. Besides cost savings, openly licensed materials could also be more accurate than traditional textbooks, because they can be updated continually as content changes. Finally, the strategy states that openly licensed materials allow teachers to exercise their own creativity and expertise, so they can tailor learning materials to meet the needs of their students (van der Vlies, 2020).

The NETP includes the following recommendations:

Support the development and use of openly licensed educational materials to promote innovative and creative opportunities for all learners and accelerate the development and adoption of new open technology–based learning tools and courses.

Similar to those leading state and local efforts under way in California, Illinois, and Washington state, administrators and policymakers at all levels and in formal and informal spaces should con- sider the diversified learning paths and potential cost savings inherent in the use of such openly licensed resources (Department of Education of the United States, 2017).

Use technology to provide all learners with online access to effective teaching and better learning opportunities with options in places where they are not otherwise available.

This goal will require leveraging partner organisations and building institutional and teacher capacity to take advantage of free and openly licensed educational content such as those indexed through Learning Registry’s #GoOpen Node (LearningRegistry.org).

Adequate connectivity will increase equitable access to resources, instruction, expertise, and learning pathways regardless of learners' geography, socioeconomic status, or other factors that historically may have put them at an educational disadvantage (Department of Education of the United States, 2017).

Curriculum and business administration choices

As noted by van der Vlies (2020), the NRTP argues that AI can help students to see patterns in the work of students, and support teachers by using student expression as an instructional resource. The NETP also focuses attention on technology-based assessments, which enable new activities, such as graphic response, simulations, and performance-based assessments that allow students to construct an original response rather than selecting the right answer from a list. Real-time feedback, increased accessibility (for example for students with special needs), adaptation to students' abilities and knowledge, and embedment with learning processes are viewed as important advantages for digital assessment (van der Vlies, 2020).

Staff training

The NETP includes the following recommendations:

Provide pre-service and in-service educators with professional learning experiences powered by technology to increase their digital literacy and enable them to create compelling learning activities that improve learning and teaching, assessment, and instructional practices.

To make this goal a reality, teacher preparation programs, school systems, state and local policymakers and educators should come together in the interest of designing pre- and in-service professional learning opportunities that are aligned specifically with technology expectations outlined within state standards and that are reflective of the increased connectivity of and access to devices in schools. Technology should not be separate from content area learning but used to transform and expand pre- and in-service learning as an integral part of teacher learning (Department of Education of the United States, 2017).

Develop a teaching force skilled in online and blended instruction.

Our education system continues to see a marked increase in online learning opportunities and blended learning models in traditional schools. To meet the need this represents better, institutions of higher education, school districts, classroom educators, and researchers need to come together to ensure practitioners have access to current information regarding research-supported practices and an understanding of the best use of emerging online technologies to support learning in online and blended spaces (Department of Education of the United States, 2017).

Develop a common set of technology competency expectations for university professors and candidates exiting teacher preparation programs for teaching in technologically enabled schools and postsecondary education institutions.

There should be no uncertainty of whether a learner entering a PK–12 classroom or college lecture hall will encounter a teacher or instructor fully capable of taking advantage of technology to transform learning. Accrediting institutions, advocacy organizations, state policymakers, administrators, and educators have to collaborate on a set of clear and common expectations and credentialing regarding educators' abilities to design and implement technology-enabled learning environments effectively (Department of Education of the United States, 2017).

Technical support

No information found.

Cyber security

The NETP includes the following recommendation:

Include cybersafety and cybersecurity training for students, teachers and parents as part of district and school "Responsible Use Policy" training.

Crimes against children and youth and the tactics to ensnare them are becoming more sophisticated. Because children often use devices both in and outside of school, cybersafety and cybersecurity should be incorporated into Responsible Use policies and trainings. The Department of Education provides several resources to support states, schools and districts (Department of Education of the United States, 2017).

How (and by how much) infrastructure is funded, and how this investment is supported and delivered

The Office of Educational Technology website lists the following federal connectivity initiatives:

BroadbandUSA: The National Telecommunications and Information Administration's (NTIA) BroadbandUSA programme promotes innovation and economic growth by supporting efforts to expand broadband connectivity and meaningful use acrossthe USA. BroadbandUSA provides resources to state, local, and tribal governments, industry, and non-profits, including a Federal Funding Guide and Indicators of Broadband Need Map.

E-Rate: In December of 2014, the Federal Communications Commission (FCC) issued its second E-rate modernization order. Together with a similar July 2014 order, this action represented the largest overhaul of the E-rate programme in its 18-year history and increased the annual E-rate funding cap to $3.9 billion to dramatically expand high-speed Internet connectivity for the USA’s schools and libraries — moving toward the ConnectED goal of connecting 99 % of the nation’s students to high-speed broadband.

ConnectHome is a United States Department of Housing and Urban Development programme focused on increasing access to high-speed Internet for low-income households. The pilot programme launched in 27 cities and one tribal nation in the summer of 2015, initially reaching more than 275,000 low-income households and nearly 200,000 children. As part of the programme, Internet service providers, non-profits, and the private sector will offer broadband access, technical training, digital literacy programs, and devices for residents in assisted housing units.

Lifeline: At the beginning of April 2016, the FCC voted to modernize the Lifeline programme, reforming the $1.5B per year Reagan-era phone subsidy programme to turn it into a 21st Century national broadband subsidy to help low-income Americans get online. The modernization also set a floor for broadband speeds paid for by the subsidy to help ensure Lifeline users are not subscribing to second-rate internet. The budget for 2020 was $2.385 (1809 GBP) billion, to be indexed linked for future years

American Broadband Initiative: The American Broadband Initiative (ABI) is jointly chaired by designees from the Departments of Commerce and Agriculture. The ABI includes 25 federal agencies and departments engaging with industry and other stakeholders to understand ways the Executive Branch can better support the needs of communities seeking broadband investment. It also helps identify regulatory barriers unduly impeding broadband deployment, adoption or competition, and recommends steps to remove such barriers.

Evidence of the cost effectiveness of different models

No information available.

Appendix 2

Review protocol

Literature searches

Using the protocol, the researchers searched a wide range of online databases and websites which offer electronic access to most published literature, using a 3-step hierarchy to ensure searches were effective and efficient:

1. Government/agency websites as the primary, authoritative source;
2. Websites of research and policy centres/organisations, such as OECD and Eurydice which include primary source material in submissions from governments as well as summary documents and country reports;
3. Reviews of technology policy (comparative and also focusing on countries of interest) and evaluations of process, impact and cost/benefit in online academic bibliographic databases (for example ERIC, Web of Knowledge and JSTOR) and open access databases (for example Google Scholar and the Directory of Open Access Journals).

The following search terms (and variants thereof) were combined with “technology” (and variants thereof, for example “ICT”, “IT”, “digital technologies”, “EdTech”), types of educational institution (“schools”, “colleges”) and the names of the countries included in the review:

- Policies
- Priorities
- Strategies
- Decision making
- Decision
- Choice
- Choose
- Finance
- Funding
- Costs
- Investment
- Procurement

- Budget
- Purchasing
- Resources
- Infrastructure
- Devices
- Hardware
- Tools
- Broadband
- Internal networking
- Platform and Management Information System (MIS)
- Software
- Business administration software
- Curriculum software
- Staff training
- Cyber security
- Evaluation
- Impact
- Effectiveness
- Cost/benefit
- Value for money

Study Selection

Once literature and other evidence was identified, they were assessed for relevance. For secondary literature, full text papers were retrieved for those that met the inclusion criteria based on abstracts. We noted that the academic literature did not provide extensive information on decision making and funding, including cost-effectiveness, but was usually more concerned with policies regarding digital competencies in pupils and staff. However, they sometimes provided useful information on the content of strategies and other initiatives not always available in the Anglophone primary sources.

Synthesis and analysis

The findings of individual studies were summarised, synthesized and critically evaluated against the research objectives and, where studies met the quality requirements, were used in the country reports, the final report, or both.

Analysis also identified any gaps in the evidence and any challenges identified in the studies.

Referencing and Bibliography

The Harvard system has been used for in-text citations and for the bibliography. The bibliography includes only reports and journal articles used in the final report and country reports, although a list of works reviewed but which were excluded during the screening process have been maintained.

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