Digital technology in education systems around the world: Practices and policies

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Executive summary

The South Australian Department for Education's digital strategy, *Delivering Digital 2016-2020*, expired in 2020. The Department's future-focused strategy aims to use digital technology to improve teaching and learning experiences; maintain modern, smart, efficient and streamlined workplaces; and better prepare South Australian children and young people to learn, live and work in a digital world. This report undertakes a review of the use of digital technology in education across 14 countries, highlighting how these high-performing public education systems have successfully integrated digital technology to enhance teaching and learning. These educational systems were selected based on their high standing and continuous improvement in various international assessments.

The first section of the report examines teacher and student digital literacy. The review demonstrates the strong focus of government initiatives on building teacher competencies with digital technologies to support student learning. Without adequate training, teachers do not feel confident to integrate technologies into their classroom (e.g. Finland, Japan). Conversely, when teachers receive adequate professional training, their confidence increases and their willingness to use technologies in their classrooms also increases (e.g. Ireland, Portugal). From a systems point of view, high-quality leadership and teacher training are the most crucial factors in ensuring effective use of technology in classrooms.

The strategies and instruments that have been put in place by countries act to promote technology use in classrooms. However, research on the effect of technology on increased learning performance is largely unknown due to confounding variables and lack of direct assessment of policy impact. There is a need for multilevel evaluation studies to probe the impact of national policies on the use of technology in education and its impact on student outcomes. For example, countries have demonstrated a significant range in reported use of digital devices by students, but a study by the Programme for International Student Assessment (PISA) did not find a significant relationship between the amount of time students spent using digital devices for schoolwork and their reading performance. This finding suggests that the way digital devices are used matters more than the length of usage. Policy impacts on design and pedagogical decisions are not generally assessed.

Most countries focus on student digital literacy. Policy and implementations vary by country, but examples include: teaching students the ability to access digital media and to modify, create and use technologies; and teaching them to become critical consumers of digital information with the aim of improving inclusion and participation in a digital society (e.g. Slovenia). Investments in digital literacy are seen as important drivers for economic growth and welfare in a knowledge-based society. Research, however, shows that digital literacy initiatives require further in-depth research in order to assess the impact of ICT policy interventions and to capture how technology is used in classrooms and in schools.

This report also explores how different countries have tackled the first digital divide (i.e. inequality in access to technology) and the second digital divide (i.e. inequality in terms of digital skills and usage of digital technologies). While most countries have ensured the provision of internet access for students to close the first digital divide, many disparities still exist around the second digital divide. PISA results, for example, have shown that students from advantaged backgrounds are more likely to use the internet to read the news and to get practical information, while students from disadvantaged backgrounds are more likely to use their digital devices to play or chat online (OECD, 2020a). Additional research is required to assess the reasons for this discrepancy. Successful approaches that countries have adopted include the delivery of specialised programs to support all students. For example, Ireland and New South Wales (NSW), Australia implemented a specialist program to improve the digital literacy of disadvantaged students and put measures in place for a more equitable distribution of resources to support the needs of individual schools.

This report also draws attention to those public education systems that have successfully improved performance and increased the wellbeing of their students through the adoption of safe and secure digital spaces. Providing cyber security guidelines and infrastructure to support students in an online environment has translated into communities engaging more with digital technologies, which, in turn, has increased digital literacy (e.g. Estonia, South Korea). New Zealand, Scotland, Japan and Singapore are standout examples of countries that are maximising the use of data to inform their education systems by adopting learning analytics. This approach positioned these education systems to develop and integrate artificial intelligence (AI) into classrooms well before other countries.

When implementing new digital technologies in the classroom, teachers' attitudes and sense of confidence and self-efficacy are important. To boost teachers' skills and confidence in using new technologies, adequate professional development opportunities need to be available, focusing on pedagogy as well as technology. Professional learning networks offer a significant opportunity to build teacher capacity and confidence in their digital ability, and countries such as Portugal and Slovenia have been successfully relying on these communities of practice to promote peer learning among teachers. Further, 'reform fatigue' must be also considered when deploying digital technologies. One way of mitigating this challenge is to increase stakeholder involvement early in new projects to ensure diverse voices and adequate representation from the primary users of new tools and technologies. This can be achieved by forming steering committees (e.g. NSW, Ireland, Slovenia) and by having open calls for proposals (e.g. Germany).

Education systems can benefit from data to inform decision making. Countries are putting a priority on improving education through better use of data analysis and foresight. Poland, for example, has adopted data-driven decision making into their education practices to improve the process of school performance evaluation. Australia (e.g. NSW) and New Zealand encourage the sharing of data and evidence with broader communities and stakeholders to capture innovative teaching and learning practices and improve the education system as a whole. Investments are made to enhance data and learning analytics based on integrated actionable data gathered at school and systems level (e.g. NSW). Data, the report shows, is used to inform personalised learning (e.g.

Estonia, Scotland, Finland), support experimentation and innovation (e.g. Singapore), and curriculum modernisation (NSW, New Zealand). The 'data trend' set by learning analytics adoption is furthered by an increased interest in the use of AI to support and augment learning. Within NSW, AI is used to improve student administration and school management processes (e.g. use of chatbots, systems integration and digitalisation of paper-based processes). Support for personalised learning is on the horizon. Similarly, Singapore is exploring how the integration of AI into school curricula can help develop digital and AI competencies and prepare students for AI adoption in society. Globally, there is a trend in governments investing in research into the use of AI in education to empower learning, and innovative countries are preparing for this next generation of technological change.

This review presents insights from best practice in the transformational adoption of technology in education. These recommendations are presented to inform the Department's digital strategy, supporting the aim of maximising the potential of digital technology to achieve world-class education for South Australians.

1. Introduction

Advanced technologies such as Artificial Intelligence (AI) will dominate the future. The coming generation of citizens and emerging workforce will need to be capable and comfortable with technology in order to thrive. There is a clear imperative for high-quality integration of technology into schools to help shape and build the required skills. UNESCO (2020) emphasises this in noting that a core aim of education should be to prepare young generations to become future ready. An effective education system should help them to deal with the rapid development of technologies and continuous access to vast amounts of new knowledge and information, while at the same time fostering critical thinking, sensemaking, creativity and collaboration skills to excel in digital contexts. To ensure that this happens, governments and schools need a digital strategy that offers guidance on implementing digital systems, technologies, digital learning design, and pedagogy and that can provide a basis for benchmarking performance against evidence-based criteria and conditions for success.

As the current digital strategy of the South Australian Department for Education is at the end of its life cycle, developing a new strategy presents an opportunity to recast technology as a transformational tool and a driver of world-class teaching and learning in South Australia. Digital technology can be adopted and integrated to improve teaching and learning experiences, maintain modern, smart, efficient and streamlined workplaces, and prepare children and young people to learn, live and work in a digital world. As with other existing educational transformation frameworks (for example, ISTE 2016; Haynes & Shelton 2018; Microsoft Educational Framework, 2014), this new strategy aims to guide a holistic transformation and draws on evidence to facilitate a well-structured and rigorous process. The Department has undertaken several activities to ensure broad consultation and in-depth research that will best guide the strategy development process and prioritisations.

2. Methodology

This report reviews the approaches and strategies developed and implemented by 14 countries and jurisdictions to support digital education:

- New South Wales, Australia
- Estonia
- Finland
- Germany
- Ireland
- Japan

- New Zealand
- Poland
- Portugal
- Qatar
- Scotland, UK
- Singapore
- Slovenia
- South Korea

These countries were selected based on factors such as PISA results (e.g. Finland, Estonia), a noteworthy increase in PISA performance over the last five years (e.g. Qatar, Slovenia), their global perception as leaders in the fields of education and specifically digital education (e.g. Ireland, Scotland) and, finally, based on data from the American National Centre of Education and the Economy information. Using individual country reports and policy documents published by individual nations and jurisdictions, two key research questions were proposed for this report:

1. How do other high-performing public education systems (in terms of quality, equity and efficiency) integrate digital technology for teaching and learning?
    a. What methods and technologies are used?
    b. Can we ascertain the extent to which digital technology is a factor in performance?
    c. To what extent is there variance across high-performing countries in terms of what is used and how?
2. Of those public education systems that have improved performance in recent years, how and to what extent was digital technology a factor?

Addressing these questions was challenging as the outcomes and effectiveness of digital strategies are often not reported. Moreover, discerning what outcomes are actually caused by students' use of digital technologies remains controversial despite the quantity of research emerging in the field of digital education. Policymakers are aware of these challenges and many countries are facing the same hurdles when it comes to access to digital technologies, online risks, and building a new generation of digital citizens (Burns & Gottschalk, 2019). Policies and programs have been developed and implemented to tackle these challenges and are described in this report (see Appendix A for further details).

The documents referenced in this report were accessed via individual government websites, typically in the form of policy documents. This report also relied on publications authored by the Organisation for Economic Co-operation and Development (OECD), UNESCO and the European Commission. Finally, the conclusions supporting this report are also derived from academic publications commissioned by individual governments.

3. Improved and enhanced teaching and learning

3.1 Teachers' competencies and digital literacy

To improve and enhance teaching and learning, governments are increasingly focussing on developing teacher competencies in the use of digital technologies. Examples from seven countries are used to illustrate differences across systems and the range of strategies designed to improve teacher digital competency. Examples include Finland (Section A.3.1), Germany (Section A.4.1), Ireland (Section A.5.1), Poland (Section A.8.1), Portugal (Section A.9.1), Scotland (Section A.11.1), and Slovenia (Section A.13.1).The overarching finding across all seven country reports and academic literature indicates that, in order to integrate digital technologies in education, countries must provide 'systems level' approaches that support the development of high-quality teachers and leadership. Contemporary education systems realise the importance of continual professional development and understand that, as technology develops, teachers require flexible information and communications technology (ICT) strategies that can support their development and ability to integrate and update the technologies used in their classrooms. For example, Portugal has been running a 'Digitalisation Programme for Schools', with professional development as the central area of focus. They initiated 'Future Classroom Labs' intended to establish communities of practice to promote peer learning (OECD, 2021a). These labs allow teachers to reflect on the impact of new technology in classrooms and to develop digital literacy. As an outcome, this initiative encouraged growth in technology adoption in classrooms and students have been more actively engaged in the learning process (European Schoolnet, 2019a).

Ireland presents another example, where the UNESCO 'ICT Competency Framework for Teachers' (ICT-CFT) was adapted to the Irish context.[1] The ICT-CFT was used to design pre-service and in-service teacher training (Department of Education and Skills, 2015). ICT was embedded into the professional development design, development, and delivery to reflect real classroom practice in action. This approach has been highly successful, and a recent review of this strategy has shown that teachers gained confidence in their digital abilities and were more willing to use digital technologies (Department of Education and Skills, 2020). Similar trends have been observed in other countries, and further detailed examples can be found in the following sections of this report: Finland's 'Digital Skills Program' to develop teacher competencies in digital literacy (Section A.3.1), Germany's 'Education in the Digital World Strategy' (Section A.4.1), Ireland's 'Teaching Learning and Assessment Using ICT' programme (Section A.5.1), Poland's 'Digital Poland Strategy' (Section A.8.1), Portugal's 'Future Classroom Labs' (Section A.9.1), Scotland's 'Digital Learning and Teaching Strategy' and national Glow platform (Section A.11.1) and Slovenia's 'E-Education Project' (Section A.13.1).

[1] https://en.unesco.org/themes/ict-education/competency-framework-teachers

All the country programs investigated have a strong emphasis on developing teachers' skills and competencies to implement digital technologies into their classrooms. In an international survey, Schleicher (2020b) identified that learning how to use ICT in the classroom was the second-highest area of professional development need reported by teachers. The 2018 Teaching and Learning International Survey (TALIS) noted that 56% of teachers had received formal education or training in the use of ICT for teaching across the OECD. However, only 43% of teachers feel prepared to use ICT in their teaching (this percentage drops down to 30% in Estonia, 28% in Japan, and only 21% in Finland). As a result, Finland and Estonia have adopted training programs that continue to encourage teachers to increase their confidence using digital technologies. In addition to the training, teachers in Estonia teachers are also provided with an online environment to help prepare student assignments and tests as well as access to e-learning materials and teaching resources that help to integrate a digital curriculum. In both countries, there is as yet no evidence to determine whether or not these programs have been successful. However, the 2018 TALIS reports that pre-service training and professional development that covered ICT skills points to an increase of ICT use by teachers in their classrooms (Loi, 2020; Schleicher, 2020b).

In summary, the importance of developing adequate teacher training for digital competencies is crucial to ensuring digital policies are adopted and utilised by teachers in classrooms. Addressing the issue from a systems level is the most appropriate approach as it ensures teacher training can be similar and comparable across each country. The countries in this report have actively put in place strategies and instruments to help increase teacher digital competencies and use this as a lever to grow the use of digital technology in the classrooms. Yet the question to what extent technology is a key factor in explaining their improved learner outcomes is largely unknown. There is a need for multi-level evaluation studies to explain the impact of these initiatives on how these educational systems improve student academic performance.

3.2 Student's literacy and numeracy

Digital technologies are critical supports in helping students develop literacy and numeracy. Globally, societies are transitioning from a print-based culture to a faster-paced screen-based digital culture. This raises the obvious question, 'how is this digital immersion shaping how children learn how to read and be numerate'? The answer must consider a multitude of factors, including how digital education tools are presented to students and for how long students engage with them.

A recent PISA report published by the OECD showed that more than 90% of students in Australia, Finland and New Zealand said that they used digital devices for learning (OECD, 2021b). In contrast, 73% of Japanese students reported not using them at all in the month prior to data collection (OECD, 2021b). Slovenian and Japanese students only spend 23 minutes per week and 10 minutes per week, respectively, using digital devices. It is worth noting that there was no significant relationship between the amount of time students spent using digital devices for

schoolwork and their reading performance.[2] This important variability between countries suggests that the way digital devices are used matters more than the length of usage. Within New Zealand, an evaluation of the Manaiakalani cluster of schools in Tāmaki, Auckland, demonstrated accelerated writing and numeracy achievement across schools when digital tools were used in the classroom (Jesson et al., 2016). The Scottish government also realises the importance of developing strong numeracy skills and has created a mathematics hub for teachers to interact with on their 'Glow' platform (OECD, 2021a). The purpose of this platform is for teachers across the country to share resources that can support the development of student numeracy. There are no current reports on the effectiveness of this specific program; however, based on PISA results, Scotland has scored above the OECD average for numeracy since the introduction of Glow, suggesting this approach may positively impact students.

3.3 Students' digital literacy

Enabling students to acquire the knowledge, skills and competencies to live and learn in the digital world is a significant challenge (Van der Vlies, 2020). Most countries have placed students' digital literacy on their digital agenda, but they have used different definitions. The main distinction lies between the generic skills needed to live in a digital age and more specific skills needed to use and apply technologies (Van der Vlies, 2020). In Slovenia, for example, digital literacy refers to both generic and specific skills and is viewed as a precondition for inclusion and participation in the digital society. The Slovenian government states:

> Only digitally literate or e-competent citizens can fully communicate digitally, use modern ICT, develop new skills in different life circumstances, be innovative and creative in the use of ICT, while in-depth understanding of ICT allows them to modify and create new technologies, solutions and ideas of use. (Government of the Republic of Slovenia, 2016, p. 40)

Similarly, Germany proposes a comprehensive definition of digital literacy, which includes digital competence as a basic understanding of digital systems, algorithms and coding. According to the Portuguese Digital Education Strategy, digital literacy is defined as 'the ability to access digital media and ICTs, understand and critically assess contents, and communicate effectively' (Government of the Republic of Portugal, 2017, p. 4). From 2015 to 2017, the Portuguese General Directorate of Education promoted the pilot project 'First Cycle Primary School Programming Initiative'. Whilst this project had many aims (Section A.8.2), it was successfully able to teach students how to critically consume information online and has helped students distinguish facts from opinions. This nationwide success highlights how investment into digital literacy can be beneficial to student learning outcomes.

[2] Reading literacy is defined by PISA as the ability to understand, use and reflect on written texts in order to achieve one's goals, to develop one's knowledge and potential, and to participate effectively in society and therefore is a direct measure of literacy OECD (2020a).

The Finnish and Estonian governments have demonstrated that their cross-curricular digital literacy topics have taught their students to be more critical consumers of digital information. The curriculum in both countries focuses on developing good research and critical thinking skills. Recent research shows the benefit of this increased focus on digital literacy as students in these nations are better at identifying 'fake news' compared to most other European countries (Charlton, 2019). Ireland also scores highly on a list of 35 countries included in the Charlton report and also has a robust digital literacy component in its curriculum. Within Germany (Section A.4.2), the government has committed to a five year plan called the 'Digital Pact for Schools' (2019-2024) which is part of the 'Education in the Digital World' strategic concept aimed to address national standards for digital education and literacy in schools and thus support student digital literacy and competencies (Kultusministerkonferenz, 2016). The plan was developed in collaboration with all federal states and relevant stakeholders (such as the science sector, unions, professional associations, schools). It contains six competence areas to promote the development of digital skills and competencies of students in schools: 1. Searching, processing, storing, 2. Communicating and cooperating, 3. Producing and presenting, 4. Protecting and acting safely, 5. Problem-solving and taking action, and 6. Analysing and reflecting. The plan is intended as a cross-cutting strategy working across the curriculum, rather than being confined to specific school subjects

The sections above have addressed policy initiatives for the development of student digital literacies and competencies in schools. Investments in digital literacy and media literacy are seen as important drivers for economic growth and social welfare, contributing to competitiveness in a knowledge-based society (Kupiainen, 2011). Policymakers are interested in systematic, comparable and generalisable data in an attempt to understand the impact or performance of their initiatives. This makes large surveys, often focussing on media and device usage, and individual skills and competencies, more common than qualitative studies such as thick descriptions or contextual studies. However, understanding the impact of large-scale policy initiatives investing in ICT in relation to education may not have the desired outcomes (Sharma et al., 2016). According to Sharma et al. (2016):

> Policy-wise, making ICT available to the young is a starting point, however, practically ensuring their productive usage is another. For example, one difficulty is realizing continuity between school and home. Visions of learning anywhere, anytime depend not only on the state's provisions for online learning in schools, but also on parents' provisions for internet access at home. Another difficulty is that educationists still conform to traditional scholastic aptitude testing systems that filter out the broad skills that ICT inspires in learners; skills pertaining to exploration and learning for fun, and being imaginative, creative and fluid in thinking. Consequently, this impacts several aspects of interest in the investigation of digital literacies as a contributor to sustainable development. (p. 631)

In their grounded theory-based study, Sharma et al. (2016) explored five countries (Singapore, Finland, New Zealand, Hong Kong and Qatar) and found that even though these countries demonstrated higher-order knowledge and technology-based investments in education together with elevated social capital for the process of education in the form of respect and rewards, the OECD (2015) report concludes that PISA scores in these countries have not increased in parallel with the use of computers in the classroom. Sharma et a. (2016) conclude that digital literacy initiatives are not ends by themselves but means to an end. They suggest that further longitudinal cases studies and ethnographic studies may help to provide narratives or rich pictures of the ICT policy interventions to capture lessons learnt and contribute to a general theory of digital literacy, knowledge societies and sustainable development.

4. Digital maturation and wellbeing

4.1.1 Equity and inclusion: Targeting the digital divides

Equity and inclusion are vital to ensuring that all students have access to technologies to help them reach their potential. When looking at the practices developed by the countries in this report, we see a similar trend in South Australia. National strategies aim to develop digital technology and internet infrastructures in order to broaden access and improve the experience and impact of teaching and learning with digital technologies in schools. As such, this section addresses the first digital divide (inequality in access) and provides various country examples of how nations work to narrow the gap from a systems level. The subsequent section will focus on lessening the second digital divide (inequality of skills and usage). It will highlight what specific technologies countries have successfully used to make this space more equitable for all. Appendix B summarises how each country is addressing the digital divides and integrates digital technologies across their curriculums.

4.1.2 First digital divide

The first digital divide refers to the gap between those able to benefit from access to the internet and ICT infrastructure and those who cannot. Countries worldwide have developed strategies to ensure students and teachers have the necessary access to ensure this gap is closing. In 2015, 91% of 15-year-old students who participated in the PISA survey reported that they had access to a smartphone, and 74% of students had access to laptops (OECD, 2019). In 2018, almost one computer for every 15-year-old student was available at school for educational purposes (computer-student ratio equal to 0.8) on average across OECD countries (OECD, 2020a).

Specific country examples in relation to tackling the first digital divide include: Japan (Section A.6.2), Poland (Section A.8.3), Portugal (Section A.9.3), Qatar (Section A.10.2), Scotland (Section A.11.2), Slovenia (Section A.13.2), and South Korea (Section A.14.1). Across these country examples, the most common method for tackling the first digital divide includes providing an adequate internet connection for students (see also Appendix B).

4.1.3 Second digital divide

The second digital divide separates people who have or do not have the competencies and skills to benefit from computer use (OECD, 2019). Simply giving students access to digital technologies will not ensure equality of opportunities. Despite being labelled 'digital natives', modern students face inequalities in terms of digital skills and motivation (Mascheroni & Ólafsson, 2016), highlighting the need to develop digital literacy (UNICEF, 2017). Not only are there differences between students in terms of digital skills, but students also use technology differently. PISA results have shown that students from advantaged backgrounds are more likely to read the news and use the internet to get practical information, while students from disadvantaged backgrounds are more likely to use their digital devices to play or chat online (OECD, 2016). We draw attention to examples from three countries that are successfully tackling the second digital divide: Australia (NSW) – in relation to special needs programs, equity and priority areas (Section A.1.2), Ireland – to advance students at socioeconomic risk and those with special needs (Section A.5.2), and Slovenia – increased focus on digital competencies and digital transformation (Section A.14). A common theme emerging from these examples is the provision of programs to improve outcomes for disadvantaged students.

4.2 Digital wellbeing

Student wellbeing in the digital age is crucial. This section outlines how countries have developed practices and policies to protect their children in an online space, highlighting how public education systems have improved both the performance and wellbeing of their students by adopting safe and secure digital spaces. The role of education in improving children's wellbeing and the relative responsibilities of families, schools and ministries have long been debated. It is becoming more common to see national strategies for coordinated policies across ministries and levels of government, but they are far from ubiquitous (Burns & Gottschalk, 2019). Developing local or national policies are insufficient in a global digital world, where more international efforts are required.

4.2.1 Cyber-bullying

A critical factor in addressing digital wellbeing is ensuring that students are protected and safe in online environments. In 2020, numerous countries, including Argentina, Costa Rica, Spain, Croatia, India, Canada, Greece, Luxembourg, South Africa, Morocco, Mexico, Portugal, France, Germany, Singapore, Slovakia, Slovenia, Tunisia and the United Kingdom signed the call for an internet Code of Good Practice to combat cyber-bullying. UNESCO launched this global initiative to manage the safety and wellbeing of students online. A number of countries have taken steps to support students and families to manage the risks of cyber-bullying at a national level. Most initiatives include providing schools with information about cyber-bullying, and/or introducing disciplinary measures and sanctions. Ireland's digital strategy outlines methods to reduce cyber-bullying, such as adopting a behaviour policy with disciplinary measures attached. Ireland has been successful in minimising the presence of cyber-bullying among students. Similarly, Poland

also has a behaviour policy that gives specific schools the power to impose sanctions on students for behaviour that is considered against its policy (e.g. disciplinary measures could lead to the suspension of the perpetrator). Poland has lower levels of cyber-bullying in comparison to other European Union nations. South Korea is planning a similar approach and aims to introduce laws making cyber-bullying education compulsory in order to protect students (The Cybersmile Foundation, 2020; see Section A.14.2). In NSW, the *Voice of Schools* handbook provides educators with information on the digital learning strategy and outlines priority areas, including eSafety. This handbook protects students as well as provide guidelines on how to address any issues that arise. Other governments have emerging strategies and initiatives. The Estonian Government, for example, has begun to consult with young people on child-related issues such as cyber-bullying to provide more nuanced ways to support students (Dalla, Di Pietro, & European Parliament, 2016). In 2021, the focus of the Singaporean Government has been on cyber wellness and protecting their students in an online environment through education of the risks and dangers online (see Section A.12.1).

4.2.2 Privacy, security and safety

To ensure students can learn effectively and safely online, security and safety policies exist across the digital strategies reviewed. All 14 of the countries included in this review have safety and security policies that are driven from a systems level and government approach. Japan, Finland and South Korea's strategies are considered exemplary and are discussed in further detail.

Since 2008, Japan has adopted privacy, security and safety processes in their education-based ICT environments. The government has focussed on developing secure networks and developing context-awareness environments (Myoken, 2008). Finland will gradually introduce a digital service package for continuous learning, in recognition of the need for continuous learning and for raising the level of knowledge, competence and skills. This new way of organising educational programmes and studying at systemic level will support learners and their need for continuous learning. The Finnish Government's 2021 report titled 'Digivision 2030' outlines the importance of privacy, security and safety as the nation transitions to these flexible learning environments (Nordlund, 2021).

To promote and ensure safe cyberspace in the educational area, the South Korean Ministry of Education, Science and Technology (MEST) set up the Education Cyber Security Center (ECSC) and implemented various e-safety and e-ethics campaigns and additional training programmes for their teachers. An example of an e-ethics programme and campaign is the 'Month of Information Culture' which aims to embed online information ethics and security training into teacher training (Hwang, Yang & Kim, 2010).

5. Education system operations and support

5.1 Evidence-based education and data driven decision making

At the core of many education systems is the need for decision making based on valid, real-world evidence. Data-informed decision-making in education is increasing the accuracy and precision of decisions at all levels and across relevant agencies (Newton, 2017). In fact, the sixth action of the European Union's current Digital Education Action Plan 2021-2027 is improving education systems through better data analysis and foresight.[3] Access to high-quality, timely data about students and their schools enables a comprehensive long-range view of education (Marsh et al., 2006). Such data can focus on students and their activities (e.g. grades, standardised test scores, attendance data, digital trace data, survey data); as well as school learning environment and resources (e.g. availability of different technologies, number of supporting staff, availability of specialised programs or technologies). Drawing on such data, powerful analytics and technologies are increasingly being used to develop two types of analytics: 1. academic analytics, which focus on evaluating performance of individual institutions (schools), groups of institutions, or entire educational systems, with the goal of aiding high-level decision making; and 2. learning analytics, which focus on supporting student in their learning, as well as teachers in their daily work.

While learning analytics are increasingly being used to support students in primary and secondary settings, most policy documents mainly focus on academic analytics, with the goal of supporting evidence-based decision making at a national and regional levels. For instance, looking to improve the process of school performance evaluation, Poland has adopted data-driven decision making and integrated it into their education practices since 2019. While there is currently no information on the effectiveness of such policies, the Polish Government hopes to use the school evaluation data to inform decision making at a systems level (see Section A.8.2) for a detailed summary).

Some countries and jurisdictions, including Ireland, NSW and New Zealand, encourage sharing data and evidence with broader communities and stakeholders. Schools are encouraged to capture and share innovative teaching practices with the broader teaching community to develop a solid research base so the entire education system will be better informed, such as with ICT integration in Ireland. Within New Zealand digital data and learning analytics are being utilised to support innovative learning.

Additionally, education systems integrating learning analytics are using data to inform decision making. For example, in Singapore, the education system is highly experimental, data-driven and evidence-based. The Ministry of Education uses surveys and online experiments to collect data on their student populations. Learning analytics are then employed to inform decision making. Similarly, the Japanese education system runs large-scale projects that collect large volumes of

[3] https://ec.europa.eu/education/education-in-the-eu/digital-education-action-plan_en

data, which is used to alter policy and practice. Both Australia (NSW) (Section A.1.2) and New Zealand (Section A.7.1) are adopting similar approaches to learning analytics to guide the modernisation of their curriculums. These initiatives are new in both Australia and New Zealand; therefore, there is no information on how effective these policies have been at a systems level. However, it is expected that such a data-driven approach will be impactful for educators and their students.

Personalised learning platforms are also gaining momentum in Estonia (Section A.2.1), Scotland and Finland. In Scotland, the Glow platform has functions that enable the creation of e-portfolios where learners can review their achievements and track their progress (OECD, 2021a). Additionally, in Finland, online learning platforms and individualised learning paths are being adopted across the nation to support individual student choices (Ministry for Foreign Affairs, Department for Communications, 2021).

5.2 Artificial Intelligence

The benefits of Artificial Intelligence (AI) are being recognised in fields such as technology, medicine and business. Unfortunately, AI is rarely mentioned in digital education strategies, and if it is, it is in very general terms. For example, Japan states that 'although AI is not able to replace humans, the technology easily attracts children's interest and is interesting to reduce the burden of learning guidance for teachers' (Ministry of Education, Culture, Sports, Science and Technology of Japan, 2019, cited by van der Vlies, 2020). Nevertheless, as AI becomes increasingly powerful in many sectors, and with the rise of digital education providing the data and learning analytics necessary to improve AI, it forms an integral part of the future of education and thus has been included in this report.

In education, AI is typically used in local and experimental contexts, rather than at the system level as yet (OECD, 2020a). It can be used for personalising learning and learning materials, to support students with special needs (e.g. to diagnose dyslexia and dyscalculia; Drigas & Ioannidou, 2013), and to make education more inclusive (e.g. to transcribe teacher's spoken language into text, OECD, 2020a). For example, Japan introduced English-speaking robots in 500 Japanese classrooms to improve students' oral and written English skills (Google for Education, 2019; for further details see Section A.6.1). At the system level, AI can be used to tackle and reduce school dropout rates and transform assessment methods (OECD, 2020a) (see, for example, New Zealand, Section A.7.1). The Singaporean Government is adopting a systems-level view of using AI to personalise learning and will run a pilot program in 2022 (see Section A.12.2).

Within NSW, AI is being used to improve student administration and school management processes, including automation of common transaction activities; AI and chatbot servicing of common service channels; digitisation of paper processes; greater integration of systems and improved user interfaces; and workflow support for tasks. While not included in their current strategy, the Centre for Education Statistics and Evaluation in NSW provides the promise of using AI to support personalised learning in the future. Singapore is also exploring how inputting AI into

school curricula can help develop digital and AI competencies, thus better equipping students entering sectors ripe for AI adoption (cyber-security, logistics, manufacturing and finance).

6. Challenges and opportunities

This section presents some of the main challenges that countries have faced when implementing their digital strategies in education and the policies that have been developed to address them. First, we consider how inequalities can be reduced by addressing the digital divides. We then discuss the important role of teacher self-efficacy in the implementation of digital technologies in the classroom and how professional development can boost teacher confidence and capability. Finally, we discuss how reform fatigue may be reduced by increasing stakeholder participation throughout the reform process.

6.1 Tackling digital inequalities by addressing the digital divides

Inequalities in the digital domain can reinforce existing socio-economic inequalities (DiMaggio & Garip, 2012). As discussed earlier in this report, many factors shape digital inequalities, including access to digital devices, a reliable internet connection, and skills and usage patterns (see Appendix B). It is therefore important for education systems to develop policies to address these issues simultaneously when targeting digital divides (Burns & Gottschalk, 2019; Van Deursen & Helsper, 2018). Tackling digital divides helps improve inclusiveness and avoid growing inequalities caused by the digital transformation (OECD, 2019).

Among the education systems reviewed here, schools usually promote individually owned digital devices to tackle the first digital divide. The advantage of using a bring-your-own-device (BYOD) approach is that many of the devices brought in by individual students may be more capable and up-to-date than some school computers. They can also be used to support a more student-centred, active learning approach, with students taking more responsibility for their own learning. The downside of BYOD policies is that there is a risk of increasing existing inequalities, particularly for students from low socio-economic backgrounds and families who cannot afford new devices. Some educational systems do not legislate BYOD but provide schools with information to support the implementation of school-based policies (Burns & Gottschalk, 2019). For example, NSW developed such guidelines. They suggest that each school should give information about BYOD to teachers, parents/guardians and students, involve and consult the school community in the development of school policies, and ensure the completion of a BYOD agreement from parents/guardians and students (NSW Department of Education, 2018). In Ireland, a circular was released in 2018 providing guidelines to design and implement school policies about the use of digital devices in schools (Ireland Department of Education, 2018). Schools have been required to consult parents and students on a multitude of issues, including BYOD and the appropriate use of tablets and smartphones outside of class time.

Tackling the second divide is a high priority for many countries, with various approaches focusing on promoting digital skills and inclusion (Burns & Gottschalk, 2019; see, for example, Portugal with their INCoDe.2030 project, and Ireland with their Skills Action Plan). Researchers and policy makers acknowledge that students will need more than just digital skills to thrive in the digital economy; students also need strong numeracy and literacy skills and socio-emotional skills, and positive attitudes towards school learning (OECD, 2019). Many countries – including Scotland, Ireland, Portugal and South Korea – have incorporated socio-emotional skills into their curricula to teach students how to become good digital citizens with positive outcomes. While not every country has evidence of the effectiveness of these programs, Portuguese teachers have successfully reported that their INCoDe.2030 project has had a positive impact on students' interest, motivation, participation, and autonomous learning (Oliveria & Pombo, 2016).

6.2 Improving teacher self-efficacy with continuing professional development

Digital technologies offer many opportunities to integrate better content, pedagogies and assessments (OECD, 2020a). An important and often overlooked consideration when implementing digital technologies in the classroom is teachers' self-efficacy. Teachers who are not confident using digital technologies in their work will avoid using them and instead engage in traditional activities with which they may have experienced previous success (Becta, 2004; Pajares & Schunk, 2002). Teachers' attitudes, social identities, perceived competence, and confidence levels have all been identified as factors that influence teachers' voluntary participation in ICT use (Hennessy, Ruthven & Brindley, 2005). Teachers' lack of confidence stems from, among other sources, fear of failure and their real and perceived limitations in ICT knowledge (Beggs, 2000; Balanskat et al., 2006). Studies have demonstrated that teachers' self-efficacy can be improved by completing educational ICT courses, highlighting the importance of high quality and relevant professional development (Pan & Franklin, 2011).

Aside from self-efficacy, some teachers do not believe in using digital technologies and consequently are less likely to use them and integrate them into curricular content (Hsu, 2016). To transition teachers such as these to use digital technologies in their practice, they need to be shown their value. Initial teacher training and continuing professional development programs can address this issue by discussing the benefits of using digital tools for teaching and learning (Becta, 2004). Several components need to be considered when designing training for teachers, including pedagogical training, skills training and ICT use (Balanskat et al., 2006; Bingimlas, 2009). Often, the training offered to teachers is technology-focused rather than pedagogy-focused, leaving teachers to figure out how to make it effective for their students. This situation can be improved by having training delivered by experts in pedagogy (Bingimlas et al., 2009).

Based on a community of practice, professional learning networks provide significant opportunities to build teacher capacity and confidence in the digital space. In an example of this working in practice, a pilot study conducted in Western Australia involved 28 primary and secondary school teachers collaborating through a distributed digital learning network to reflect

on and develop their digital capabilities (Sheffield et al., 2018). Some of the key characteristics of the model used in this study were: having a clear and well-defined purpose, allowing teachers to build on their knowledge and skills, using examples to model strategies to be taken to the classroom, and providing teachers with opportunities to lead reform efforts. These approaches allowed teachers to build their confidence and competence to use digital technologies and implement the digital technologies curriculum. Countries such as Portugal and Slovenia also rely strongly on professional networks to promote peer learning, exchange good practice, upskill teachers' digital competency, and boost their confidence.

6.3 Avoid reform fatigue by increasing stakeholder involvement

Attitudes towards innovation are critical for determining the success and effectiveness of the uptake of new initiatives (Katz, 2018; Knezek & Christensen, 2018). New reforms often generate a range of emotions and responses from stakeholders. Research suggests that change can be a source of anxiety for those involved in the process (Hall & Hord, 1987). The level of anxiety experienced may depend on the extent to which an individual believes the change will impact them personally (Hargreaves, 2004) and whether the innovation aligns with their attitudes and beliefs (Carless, 1997).

Reform fatigue can compromise the successful implementation of new educational reforms and needs to be considered (Dilkes et al., 2014). Reform fatigue occurs when changes and adjustments to the curriculum, or technology used, are too frequent. This is often apparent when policy changes are made before previous reforms have had a chance to be embedded into practice or when teachers are made to deal with successive, contradictory reforms (OECD, 2020a). When education practitioners navigate new reforms that affect their practice, they can experience frustration, disillusionment, and fatigue, resulting in a resistance to change over time (MacDonald et al., 2019). Resistance to change can prevent the successful integration of digital technologies in the classroom (Becta, 2004; Cuban et al., 2001).

To successfully implement new reforms, those who are most affected must be able to see that with change comes value (Hargreaves, 2002) As a consequence, individuals are more likely to take ownership of new initiatives, increasing the potential for successful reform outcomes (Flanagan & Jacobsen, 2003). This kind of process requires trust between educators and government, which can be fostered by involving different educational stakeholders throughout the reform process, for example, in the form of steering committees (e.g. 'Opening up Slovenia' and Ireland's 'Digital Schools of Distinction' project) and open calls for proposals (e.g. Hamburg's 'Start into the Next Generation'; Conrads et al., 2017). In Slovenia, the 'Opening Up Slovenia' initiative used a bottom-up approach to policy development and implementation. Various stakeholders from the education sector (teachers, principals, students) as well as businesses, industry and government, were involved in the development of the framework to support the country's digital transformation. 'Opening Up Slovenia' can be considered a think tank where every stakeholder is treated equally to discuss problems related to digital education and come up with solutions. The goal of this initiative is to design, implement, test, validate and share good practices in digital education (dos

Santos et al., 2017). In Estonia, teachers have been involved in the redesign of the new curriculum and educational e-services, the motivation being that if teachers see themselves as agents of change, they will be more enthusiastic about implementing said change (OECD, 2020a). In NSW, principals worked closely with the department's professional services team to develop the Voice of School handbook. This handbook sets out the schools' priorities and areas of need, and opportunities to develop the digital capacity of schools and staff (NSW Department of Education, 2019).

7. Conclusion

This review has presented insights from best practice in the transformational adoption of technology in education from 14 countries and jurisdictions. This report first addressed improved and enhanced teaching and learning. The evidence suggests that investment in teacher training on *how to use* digital technologies is more important than simply providing teachers *with access to* digital technologies. Countries with strong teacher professional development strategies designed to develop teacher confidence to use digital technologies find that teachers are more likely to use these technologies in their classes (e.g. Ireland). However, if teachers have not received adequate training (e.g. pedagogical training to complement technical training), they are then more likely to have lower confidence in using digital technologies and are therefore less likely to use them in their classes (e.g. Estonia, Finland, Japan). While most of the countries and jurisdictions reviewed in this report have already made remarkable efforts to close the first digital divide, tackling the second divide remains a high priority for most of them. Many successful approaches have focused on promoting digital skills and inclusion by developing targeted programs for disadvantaged students.

This report also noted the importance of stakeholder engagement when developing new policies to successfully integrate digital policies into the classroom. Countries such as Estonia have included both teacher and student opinions when developing their recent digital strategy. The Estonian Government has noted that this approach has resulted in more 'buy in' from the user as well as a more successful uptake across the country. Furthermore, the report highlighted how each country has a strong focus on ensuring the privacy, safety and security of their digital strategies, thus protecting their teachers and students. Finally, this review has also shown that the most modern and successful countries are also innovative in maximising the use of data to inform their education systems. New Zealand, Scotland, Japan and Singapore are standout examples of countries that have used learning analytics data to put themselves well ahead of the curve in the integration of artificial intelligence into classrooms.

8. References

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Appendix A: Country contexts

This appendix summarises key points from digital education strategies in the countries selected for analysis in this report. Each country has their own strategy; hence, while consistent headings were the aim of the report, they were not possible in all instances. The appendix presents each country's education context and PISA results, but demonstrating causal relationships between the digital strategy and the PISA result is impossible. Further, a limitation of the analysis provided here is that while strategies have been published, reviews and outcomes of the strategy implementation often have not been published.

A.1 NSW, Australia

The Australian education system is broadly structured as (1) primary school for 7-8 years duration, starting with foundation, through to Year 6 or 7, (2) secondary school for four years duration from Years 7 or 8 to Year 10, (3) senior secondary school for two years duration from Years 11 to 12, and (4) tertiary education, which includes higher education and VET.

The proportion of private (non-government funded) investment in Australian schools is much greater than in other OECD countries (almost 40% for Australia compared to the OECD average of 16%). Formally, education and training is a responsibility of the individual State or Territory Governments, and the Australian Federal Government provides funding and support. The situation is similar in the higher education sector.

For the purposes of this report, only New South Wales was included, including their publications, *Leading Education in a Digital World*, *Schools Digital Strategy Handbook* and *Voice of Schools Handbook* (2019-2026). In PISA 2018, Australian students across the country scored above the OECD average in reading (503), mathematics (491) and science (503) (OECD, 2020a) (see Figure 1)

Figure 1. Average overall mathematics, reading, and science scores for 15-years-old students in Australia

A.1.1 NSW data analytics

Within NSW, the state invests in enhancing data analytics and reporting through the development of advanced analytics. The Centre for Education Statistics and Evaluation (CESE) gathers student data at school level and integrates data for analysis at systems level (NSW Department of Education, 2019). In this way, CESE can develop evidence through data analytics to inform actionable advice for the Department for Education, with the aim of improving learning outcomes across the education sector. CESE conducts research and publishes evidence to show 'what works'. This evidence will produce practical resources for educators to engage with data and evidence. At a systems level, these advanced analytics will provide necessary evidence that underpins many of the digital strategy components, including personalised learning support, welfare support, and enhanced performance understanding (NSW Department of Education, 2019).

A.1.2 Addressing the second digital divide

Within NSW, the State Government is addressing the second digital divide by providing programs that support disadvantaged students and their families, such as the 'Bump it Up' program, therefore bridging the gap between those who have digital competencies and those who don't (OECD, 2019). Digital learning is being integrated into formative assessment programs and initiatives such as the Disability Strategy, which aims to equip all schools to have the support they need to educate and include the range of children in their community, and the Bump It Up program, which focuses

on lifting students from the middle bands of NAPLAN and implementing locally developed targeted initiatives to improve their performance. Additionally, the *Voice of Schools* handbook provides educators with a voice on the Digital Learning Strategy and outlines priority areas. Again, the Department aims to strengthen the equity foundations by ensuring students have access to digital technologies relevant to their age, and also involves developing more equitable digital literacy strategies to increase students and teachers' confidence and skill sets (NSW Department of Education, 2019).

A.2 Estonia

Education in Estonia begins at age 7 and finishes when students are 17. Primary and lower secondary education runs from Grades 1 through 9. Upper secondary school covers Grades 10 through 12. In upper secondary school, students choose either an academic or a vocational program.

Private schools make up less than 10% of all schools in Estonia. Whilst the state sets the national standards, assessments and sets funding, individual schools have a large degree of autonomy. Despite a relatively low expenditure on education, Estonia continues to outperform other countries in overall PISA performance. In PISA 2018, Estonia was among the top performers in all three domains assessed (OECD, 2020a).

Over recent years, Estonia has strengthened their teachers' digital skills and increased inclusive education practices, as well as increasing teacher wages. Estonian teachers feel valued, and results from TALIS 2018 highlight that this feeling had almost doubled since TALIS 2013. In PISA 2018, Estonia scored above the OECD average in reading, mathematics and science. Estonia's PISA scores have been increasing for mathematics and reading but decreasing for science (see Figure 2).

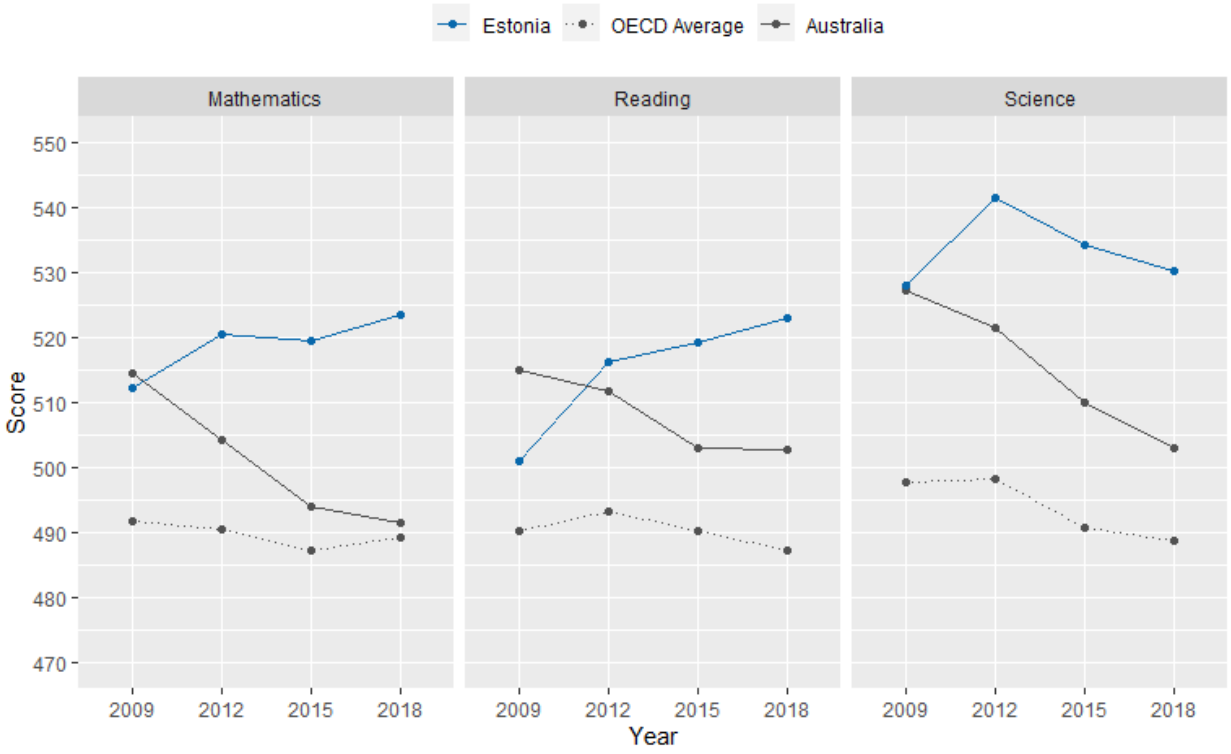

Figure 2. Average overall Mathematics, Reading, and Science scores for 15-years-old students in Estonia

A.2.1 Personalised online learning environments

In 2016, Estonia developed an online environment system which allows teachers to prepare assignments and conducts tests, including standardised exams, to monitor the development of key competencies. The aim of this environment is to ensure that both teachers and students have flexibility in their learning environments which in turn can support more effective learning outcomes (OECD, 2021a).

In Estonia, digital or e-learning materials (e-textbooks, e-workbooks, educational videos and e-tests) are used by teachers across the nation. In an interactive web environment, e-Koolikoot (E-School Bag), students can access digital study materials, and teachers can create collections of e-materials which are shared across the nation. This environment offers preschool, basic, general and vocational education study materials, with open access to all citizens. In addition, a large number of e-tasks and diagnostic tests for learning are compiled. A collection of 88 e-tasks and 69 diagnostic tests in five areas (mother tongue, natural sciences, mathematics, foreign languages and social sciences) have been published. Based on test feedback, teachers can plan further learning activities and determine what should be retaught, what should be reinforced and who should be offered individual activities. Students also receive feedback on their learning.

A.3 Finland

Comprehensive school education in Finland is from Grades 1 to 9 and is compulsory for all children. Compulsory education generally starts in the year in which children turn seven. This education is free to students as local authorities (municipalities) and other education providers pay the school fees. Public school is more common and less than 2% of children go to a private school.

Finland has a strong tradition of high educational outcomes. As in previous cycles, in PISA 2018 Finland's performance was well above average in reading, mathematics and science. After basic education, students may choose to continue with secondary education in either an academic track or a vocational track, both of which usually take three years and result in a qualification to continue to tertiary education. Whilst still being above OECD average, Figure 3 highlights that the PISA scores of Finnish students had been decreasing in mathematics, reading and science scores (OECD, 2020a).

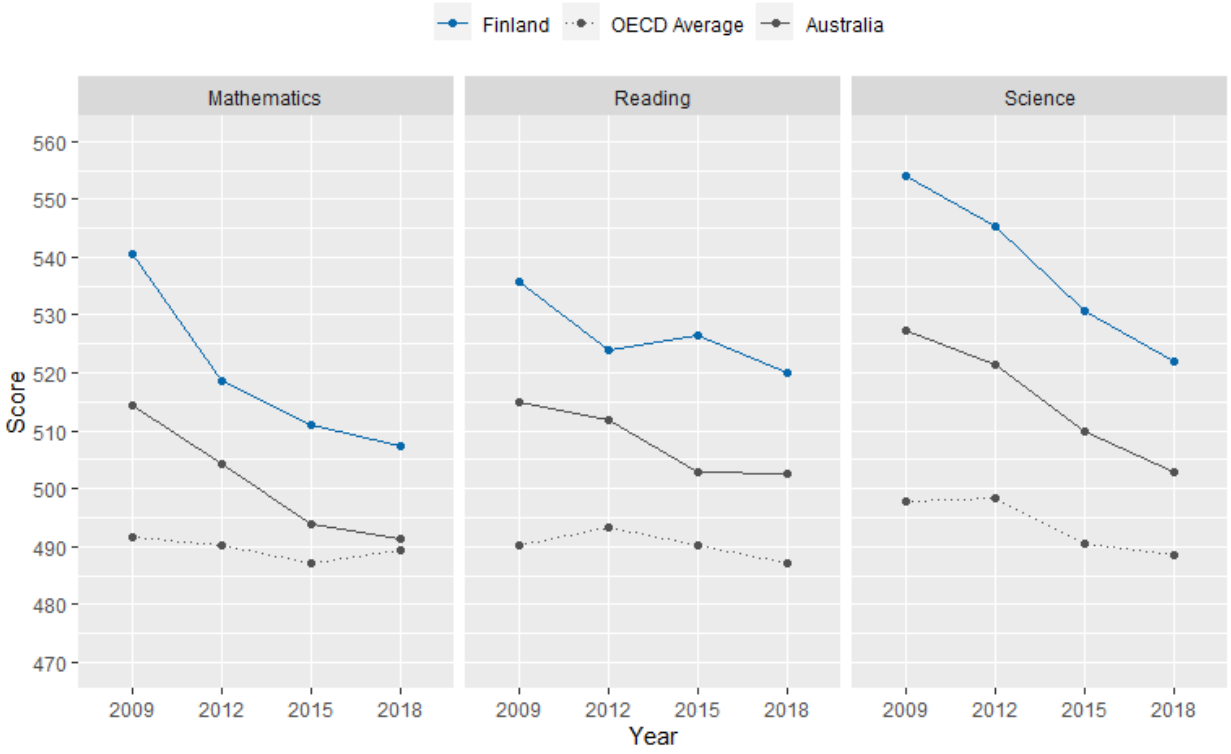

Figure 3. Average overall mathematics, reading, and science scores for 15-years-old students in Finland

A.3.1 .Developing teacher digital skills program

In Finland, The Ministry of Education and Culture launched a two-year program in 2017 to develop the digital skills of teachers across the country. The 4.5 million Euro program intended to develop teacher competencies in digital literacy by providing mentor teachers to support the use of digital tools. A 2019 review of this program found significant improvements in teachers' digital

competencies but also noted ongoing disparities in the lack of integration of digital tools in the classroom (European Commission, 2019a). Despite receiving training on how to use digital technologies, teachers in Finland are reluctant to integrate them into their teaching. This suggests that teachers may need more time developing confidence to integrate the technologies in their lesson plans.

A.4 Germany

Education in Germany is, for the most part, the responsibility of individual German states. Overall, Germany has a high-performing education system, with PISA scores above OECD averages in all three categories. However, after a steady growth of several years, there has been a notable decline since 2012 in mathematics and science, and a decline in reading at the last 2018 test (OECD, 2020a) (Figure 4). In Germany, participation in early childhood education and care is near universal among 3 to 5-year-olds. Children attend four years of primary school (Years 6 to 9) followed by secondary schooling, split into lower and upper secondary education. Within upper secondary schooling, there are different types of schools. *Gymnasiums* focus on preparing students for higher education, while *Hauptschules* prepare students for vocational training.

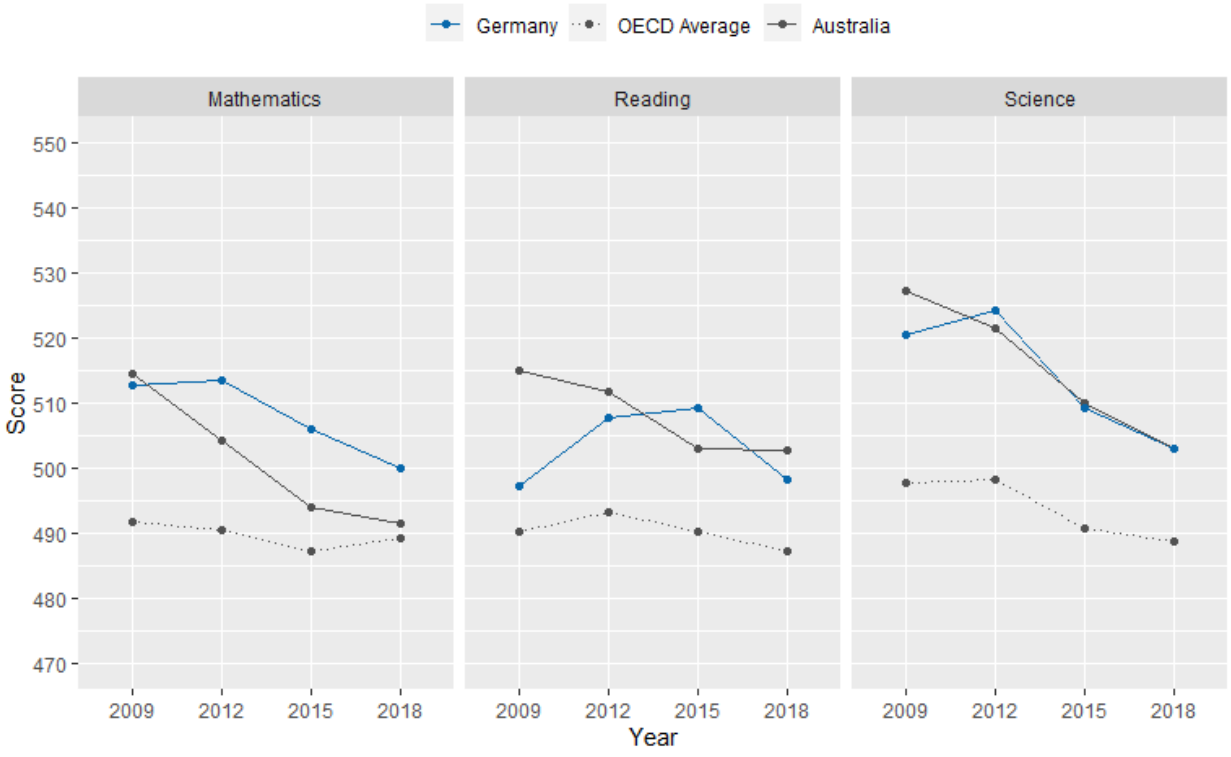

Figure 4. Average overall mathematics, reading, and science scores for 15-years-old students in Germany

In terms of digital education, the existing digital infrastructure and training programs vary significantly between German states, resulting in the underutilisation of digital technologies in the school sector (Deloitte & Ipsos, 2019). This has been emphasised by the OECD, which

recommended expanding the use of ICT in schools, and improving teachers' digital competencies and ICT-related curriculum (OECD, 2020b). To address some of the challenges, the German Federal Government announced an AUD 7.9 billion 'Digital Pact for School' initiative (Brady, 2016; OECD, 2020a) for the period 2019-2024, focusing on the development of school digital infrastructure, development of ICT-enabled pedagogical approaches, as well as improvement of students' and teachers' digital competencies. The initial uptake of the project was slow, with only AUD 24 million being distributed by mid-2020 (Chu, 2021). According to Chu (2021):

> It's only with the pandemic that a public spotlight has been turned on the effects of abysmally poor digitization levels, and the accompanying lockdown has prompted a radical rethinking of the need for digital infrastructure and teacher training.

A.4.1 2016 Education in the Digital World Strategy

Within Germany, there have been several strategies and policies focusing on the improvement of teacher digital skills. The 2016 'Education in the Digital World Strategy' outlined as one of its basic requirements the need for teacher digital literacies that allow them to teach their subjects using technology in a pedagogically sound manner. The key elements of this strategy are:

1. Development of ICT-focused teaching materials,
2. Professional development of educators and teachers,
3. Development of ICT infrastructure and equipment,
4. Educational media,
5. E-government and school administration programs, as well as campus management systems, and
6. Legal and functional framework for digital education.

With regards to teacher digital literacies, there are significant variations between different states, complicated by the different state-level specifications for teacher training and professional development. According to Deloitte and Ipsos's (2019) report on the state of the German education system, there are significant differences in compulsory ICT training participation, ranging from less than 10% to about 75% across different states. The same report also reveals that 60% of teachers learn new technologies in their free time (Deloitte & Ipsos, 2019). Unsurprisingly, 40% of pre-service teachers expect their students to know more about digital technologies than their teachers (Blume, 2020), and they see such a discrepancy as a potential threat to their role and authority as teachers.

A.4.2 Digital Pact for Schools

Within Germany, there has been a significant push towards developing students' digital competencies and skills necessary in the 21st century workplace. The 'Digital Pact for Schools' (KMK, 2019) focuses on developing such skills and involves the development of necessary digital

infrastructure, curricular, and learning materials as well as improving teacher digital literacy. The plan was developed in collaboration with all federal states and relevant stakeholders (such the science sector, unions, professional associations, schools). It contains six competency areas to promote the development of digital skills and competencies of students in schools. The competency areas are: 1. Searching, processing, storing, 2. Communicating and cooperating, 3. Producing and presenting, 4. Protecting and acting safely, 5. Problem-solving and taking action, and 6. Analysing and reflecting. The plan is intended as a cross cutting strategy working across the curriculum, rather than being confined to specific school subjects. The federal government committed about 7.9 billion AUD over five years for this program (2019-2024), which will be used to fund state-specific initiatives. Individual schools will develop their specific plans for the implementation of digital technologies (aligned with state and national objectives), which will be then submitted for financial support within their state. The goal of the pact is to have a lasting impact on educational governance by promoting innovations at regional, state and national levels, allowing for development of shared standards and necessary digital infrastructure (OECD, 2020a).

A.5 Ireland

In Ireland, education is compulsory for children from ages 6 to 16. The system is made up of primary, second, and third-level further education, with state-funded education available at all levels (and private school options). In general, primary schools are privately owned by religious communities (or boards of governors) but are state funded. Secondary schools consist of a three-year junior cycle (age 12-15) followed by a two-year or three-year senior cycle (age 15-18). Third-level education is made up of several sectors, including universities, technological providers and colleges of education, which are substantially funded by the state. There are also a number of independent private colleges.

Ireland's Department of Education and Skills (2015) published their 'Digital Strategy for Schools (2015-2020)', which was built on in the 'Statement of Strategy (2019-2021)' and taken further in Ireland's 'National Skills Strategy 2025'. The OECD Government at a Glance 2015 report shows that the level of satisfaction with the education system in Ireland was 83%; the second highest of all the European countries surveyed.[4] In PISA 2018, Irish students scored above the OECD average in reading (518), mathematics (500) and science (496) (OECD, 2020a) (see Figure 5).

[4] https://www.oecd-ilibrary.org/governance/government-at-a-glance-2015_gov_glance-2015-en

Figure 5. Average overall mathematics, reading, and science scores for 15-years-old students in Ireland

A.5.1 Teaching, Learning and Assessment Using ICT

The Irish 2015-2020 Digital Strategy for Schools embodied a 'Teaching, Learning and Assessment Using ICT' theme. This theme aimed to embed ICT into the education system at all levels. The strategy provided advice and guidance for teachers and schools that included good practice on ICT use. Further, the department used the UNESCO ICT Competency Framework for Teachers (adapted to meet the Irish context) to provide support materials and services to schools on embedding ICT into practice. Within this framework there is a theme focused on upskilling teachers with the knowledge, skills, and confidence to integrate ICT into practice. This theme was partly addressed through embedding ICT for teaching at each stage of the continuum of teacher education (Department of Education and Skills, 2015). Again, the UNESCO ICT Competency Framework for Teachers was used to inform future teacher professional development, and ICT was embedded into the professional development design, development, and delivery to reflect real classroom practice in action. A 2019 review of this strategy highlighted its success. The review demonstrated that digital learning technologies were used in 55% of lessons observed in primary schools and 62% of lessons observed in post-primary schools (Ireland Department of Education and Skills, 2020). This indicates that teachers experienced an increase in their confidence to use digital technologies and their willingness to use them.

A.5.2 Special Education needs

Ireland's 'Department of Education and Skills 2019-2021' strategy aims to advance the progress of learners at risk of educational disadvantage and learners with special educational needs to support them to achieve their potential (Ireland Department of Education and Skills, 2020). To achieve the goal, the government has committed to: (1) Implementing the 'Delivering Equality of Opportunity in Schools' action plan to close the gap in performance and increase retention rates. This includes the development of a new resource allocation model recognising more grades of disadvantage to provide appropriate resources to the needs of individual schools; (2) Exploring innovative approaches to improving the outcomes for learners at greatest risk of educational disadvantage. This includes improving inter-agency collaboration and encouraging schools to collaborate in clusters and networks to facilitate peer learning and sharing of expertise; (3) Progressing the implementation of a school inclusion model to deliver the right supports at the right time to students with additional care needs, and aimed at early allocation of special needs assistants; (4) Progressing the move towards a needs-based, responsive set of State supports for students with special educational needs, focusing on improved measurable outcomes. Improving a data-informed methodology for the identification of schools that have experienced demographic and other changes, as well a gathering better information on school performance; and (5) Implementing strands of the National Access Plan to ensure that the student body entering, participating in, and completing higher education at all levels reflects the diversity and social mix of Ireland's population (Department of Education and Skills, 2017).

A.6 Japan

In Japan, pre-primary education usually starts at age three, and compulsory education runs from age six to age fifteen. The Ministry of Education, Culture, Sports, and Science and Technology (MEXT) is the main body in charge of education in Japan. Most schooling decisions in lower secondary education are taken by regional and local governments and schools, but schools have very limited autonomy over resource management. While MEXT has introduced policies aimed at reducing competitive pressures on students (particularly for entrance to university), privately-run after-hours tutoring schools remain an important feature of the education system (OECD, 2015). In PISA 2012, Japan was among the top-performing countries in mathematics, science and reading (see Figure 6). Mean student performance in mathematics was stable between 2003 and 2018 but declined both in reading and in science (OECD, 2020a).

Japan has been slow to introduce ICT in education and the development of digital competencies has been identified as an area in need of improvement (OECD, 2019). In 2019, MEXT launched an initiative called 'Global Innovation Gateway for All' (GIGA) that allows local boards of education to provide a device for each student with a high-speed network in Grades 1 to9.

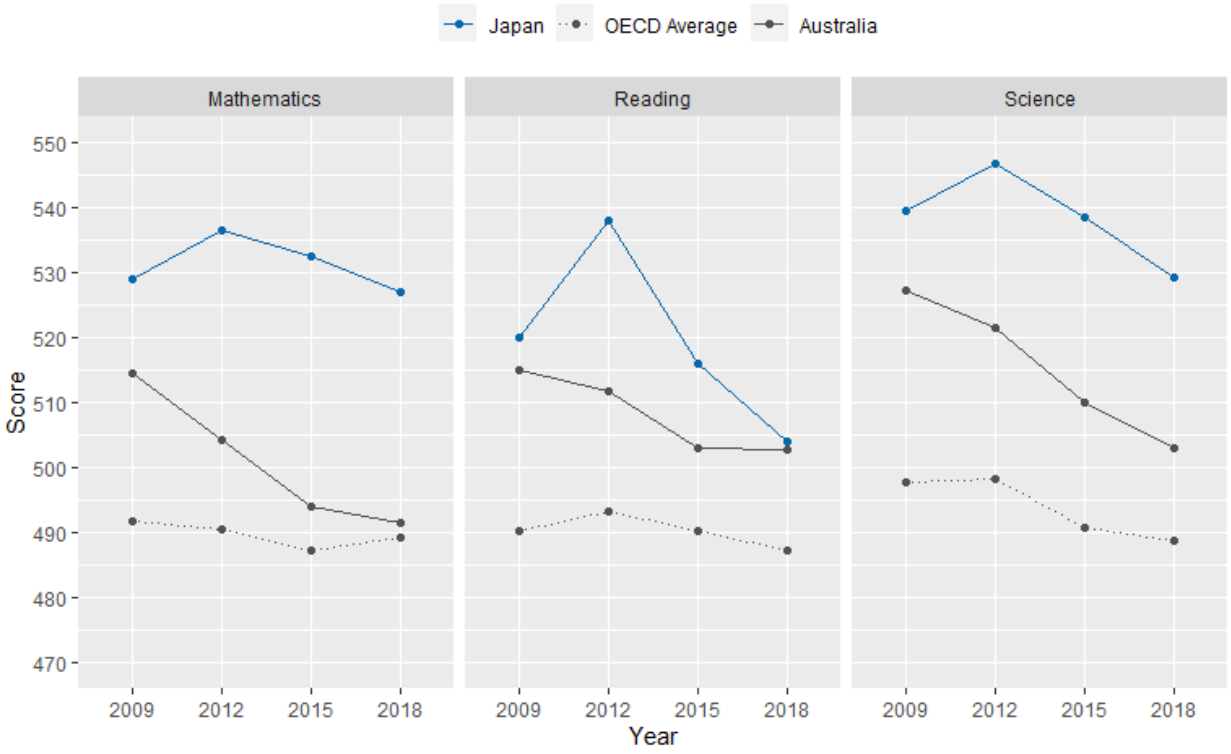

Figure 6. Average overall mathematics, reading, and science scores for 15-years-old students in Japan

A.6.1 Artificial Intelligence

In 2019, MEXT invested approximately AUD 300,000 to introduce English-speaking robots in 500 Japanese classrooms to improve students' oral and written English skills (Google for Education, 2019). This pilot project includes not only AI robots, but online lessons and tablet apps. In Japan, AI is also being used to help teachers understand the school environment. For example, the city of Otsu will be using AI to help teachers predict the seriousness of suspected bullying cases. This will allow teachers to get a better understanding of how bullying occurs and how it can be prevented in the future (Google for Education, 2019).

A.6.2 Addressing the first digital divide

Japan has struggled to close the first digital divide. Therefore, in 2019, MEXT launched the previously mentioned GIGA initiative that allowed local boards of education to provide a device for each student with a high-speed, high-capacity communication network in schools across the country. Additionally, students in Grade 1 to 9 received a top up of AUS 200 per student to support the device's purchase. Students from lower-income households will receive further subsidies so that the out-of-pocket cost is nil (Ministry of Education, Culture, Sports, Science and Technology – Japan, 2019).

A.7 New Zealand

New Zealand has compulsory education from age 6 to 16. In 2020, there were 200,000 early childhood enrolments (aged 3 to 5) and 776,000 primary and secondary school students (aged 5 to19). School is made up of either contributing school (aged 6 to 11) or full primary school (aged 6 to13) and secondary school (aged 12 to16), which can include junior and senior high school. Education providers include State schools (n = 2,100), Integrated schools (n = 330), Private schools (n = 88), and Partnership schools (n = 9). In New Zealand's education system, education providers (including early childhood education services, schools, and tertiary providers) are responsible for their own teaching and learning resources, assets, and infrastructure. However, most schools in New Zealand are owned and funded by the state, teach national curriculum and are secular. Private schools are primarily funded through school fees, however they do receive some government funding. Private schools develop their own learning programmes and are not required to follow the national curriculum.

Over the last decade, the Ministry of Education has published a range of policies, including the 'Ambitious for New Zealand Four-Year Plan (2016-2020)', 'Education System Digital Strategy' (2016), 'Transforming Education for the Digital Age' (2015-2020), the 'International Education Strategy (2018-2030)', and the 'Learning Support Action Plan (2019-2025)', all of which informed this report. In PISA 2018, New Zealand students scored above the OECD average in reading (506), mathematics (494) and science (508) (OECD, 2020a) (see Figure 7).

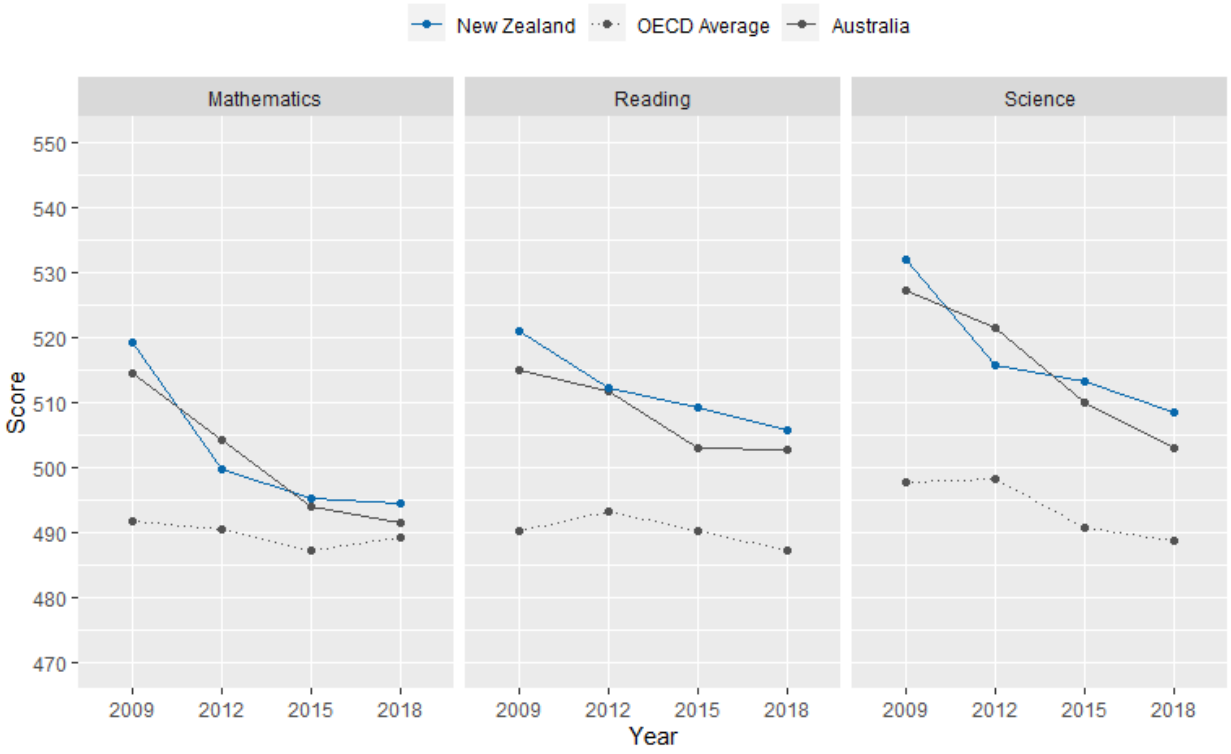

Figure 7. Average overall mathematics, reading, and science scores for 15-years-old students in New Zealand

A.7.1 Supporting high-quality teaching with learning analytics

New Zealand's education system employs a digital strategy that has student data at the core. Using learning analytics based on past achievement and future aspirations, along with an integrated student record, the strategy aims to strengthen 21st century practice by supporting high-quality teaching with integrated digital learning environments and digital assessment tools (for example, e-asTTle, PACT, NCEA Online). New Zealand aims to create communities of learning by using student data to create information dashboards and use Student Management Systems (SMS) supported by the schools' migration to the cloud. It aims to improve student-centred pathways by using student data to inform careers planning, tertiary options and occupation outlook. Integrating systems for enhanced coherence and interoperability should reduce costs to teachers and students, as it will support critical information to follow students as they move. For example, student's progress could be hindered if they transition from one educational setting to another (Newton, 2017). This risks disrupted student progress as well as vulnerable students being more likely to 'fall through the cracks', and teachers wasting valuable teaching and learning time re-evaluating and testing students already at risk (Newton, 2017). Therefore, great care has been taken with the New Zealand Student Record Transfer (SRT) system. This system allows educators to easily send student records from one school to another as the student moves, providing greater accuracy with less administration. Transfer can be done using any SMS. With SRT, an educator can transfer much more detailed information from their students' files, including enrolment details, caregiver

information; medical, assessment and attendance records. The benefits of collecting such detailed analytics include: saving administrative time and cost. Earlier and more complete information about student transfers allows for better decision making on matters like resourcing, staffing and timetabling. Additionally, this process allows for the secure storage and accurate transfer of data transfers are logged both in SRT and in the school's SMS.

A.7.2 Data-driven decision-making plan

The New Zealand Ministry for Education four-year plan outlines the intention for data to inform decision-making and direct resources and funding to where it will have the greatest effect. The education agency's digital strategy will help support this, whereby innovative learning will be enhanced, and data will be available so parents and other stakeholders can make informed decisions. This will be facilitated by better access to and use of data information to support evidence-based decision making, access to digital learning opportunities to support 21st-century practices in teaching and learning, and more efficient administration of education. The New Zealand system also suggests that improved data and information sharing will support better education outcomes for students with disabilities and learning support needs (Ministry of Education, New Zealand, 2019). The New Zealand government proposes that they will work to bring individual learners' information together, which will enable a high-level view of the educational needs of students at a school, community, and national level. The New Zealand Ministry for Education 'Learning for Action Plan' (2019-2025) states that' in the design of data infrastructure, the privacy rights of all students and their families will be upheld.

A.8 Poland

Poland has one of the top ranked educational systems, with strong performance across all three main PISA scales. In Poland, schooling starts at age six (compulsory kindergarten), with eight years of primary schooling from age seven, followed by four years of secondary schooling preparing students for the workplace or entering university. Poland has made steady progress in PISA rankings since early 2000s, with only exception of PISA 2015 (OECD, 2020a), where there was a drop in performance compared to the previous testing cycle (see Figure 8). With regards to use of digital educational technologies, the significant obstacle is lower internet use and lack of high-speed internet connections at schools, as well as outdated equipment (Plebańska & Tarkowski, 2019). To address these challenges, there have been several key initiatives, focusing mainly on developing necessary technical and network infrastructure and the provision of much-needed professional training.

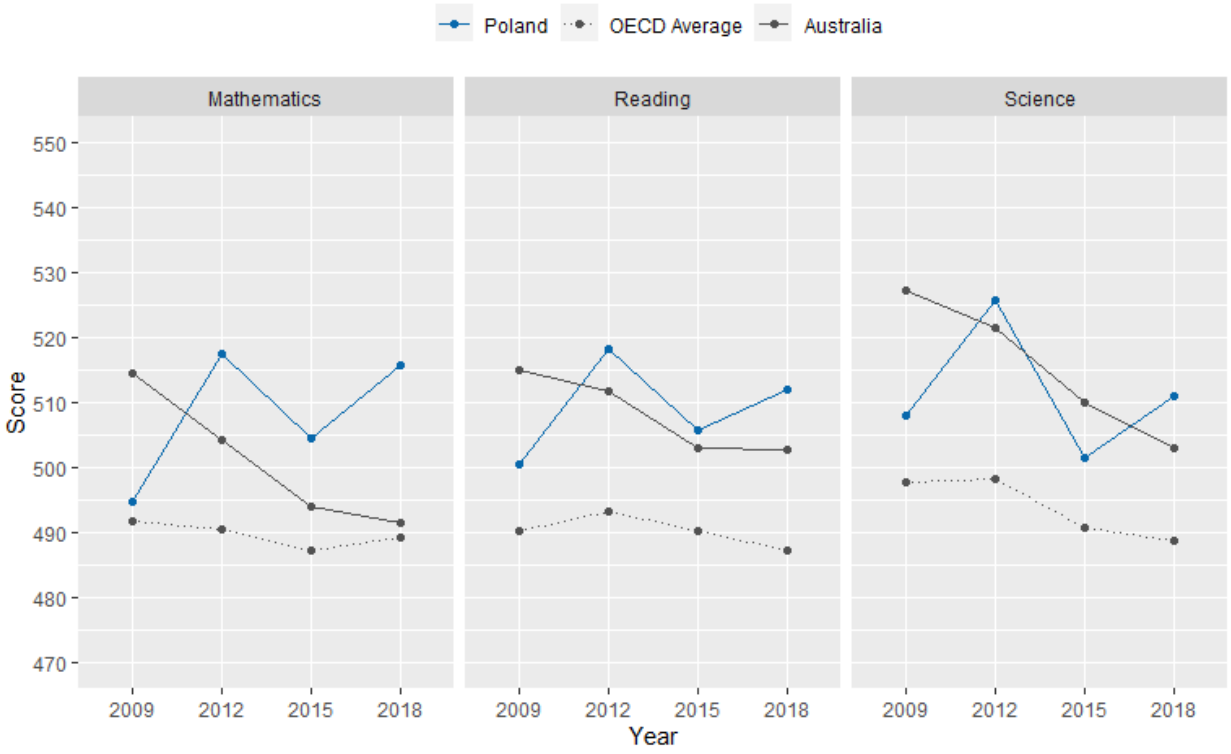

Figure 8. Average overall mathematics, reading, and science scores for 15-years-old students in Poland

A.8.1 Poland 2030

'Poland 2030 – The third wave of modernity' is one of the key programmes for supporting teacher digital literacy as part of a long-term national development strategy (Ministerstwo Administracji i Cyfryzacji, 2013). It focuses on the development of human capital and improving the quality of educational services. Within its Digital Poland strategic area, the programme includes the development of new models of educational and vocational competencies that include mandatory competencies in using new technologies for teaching different subjects. The initiative also includes systemic mechanisms for developing digital literacies, common digital learning across Poland, and new academic specialisations focused on digital education. The development of teacher digital competencies has also been part of the Polish 'Human Capital Development Strategy 2020', with the goal of increasing the use of interactive teaching methods and high-quality digital resources. Finally, one of the three funding areas for the Operational Programme 'Digital Poland 2014-2020' (European Commission, 2014) has been the development of digital literacy and use of internet, resulting in several regional projects focusing on the development of teachers' digital literacy.

A.8.2 Early approaches to data-driven decision making

In Poland, there has been a significant push towards data-driven decision making. There is a newly-developed school evaluation policy, with specific criteria relating to digital education (European Commission, 2019b). While the evaluation criteria are updated annually, the core elements include evaluation of how digital technologies are integrated into teaching and learning activities; ICT

infrastructure and connectivity; and use of technologies for school management (e.g. use of ICT for communication with parents, use of social media channels). There have been additional criteria each year, such as internet safety and responsible use of social media in 2017/18, and safe use of internet resources in 2018/19. However, as indicated by a 2019 European Commission report, the evaluation is still mainly on an ad-hoc basis. A Good Practice Data Base[5] has been developed by the Polish Educational Research Institute to provide teachers and school managers with information on quality teaching, assessment materials and other learning tools. The database contains learning resources and activities for each of the subjects in the Polish curriculum, and can be freely used by teachers in their own practice.

A.8.3 Addressing the first digital divide

In Poland, the Nationwide Education Network (Ogólnopolska Sieć Edukacyjna - OSE, 2020) has been established to overcome challenges of digital exclusion and access to ICT. Funded with over AUD 600 million (plus an additional AUD 60 million per year for maintanence over next 10 years), the goal of the project is to have ICT resources reach over 30,000 schools and five million potential users, mainly in low populated areas (European Commission, 2019b).

A.9 Portugal

In Portugal, the Ministério da Educação is the governmental department responsible for defining, coordinating, implementing and evaluating national policy regarding the education system, which covers pre-school education (3 to 6 years old), basic education (6 to 15 years old) and upper secondary education (15 to 18 years old). In PISA 2018, Portuguese students scored around the OECD average in reading, mathematics and science, maintaining considerable improvements in student performance across cycles (OECD, 2020a) (see Figure 9).

In 2017, Portugal launched the 'National Digital Competences Initiative 2030' (INCoDe.2030), which is a cross-sectoral approach to enhancing digital competencies. The aim of INCoDe.2030 was to reach 20,000 enrolments in digital literacy programmes by 2020, invest 2% of gross domestic product into research and development by 2025, and ensure that 80% of the Portuguese population have basic digital skills by 2030.

[5] http://bdp.ibe.edu.pl/

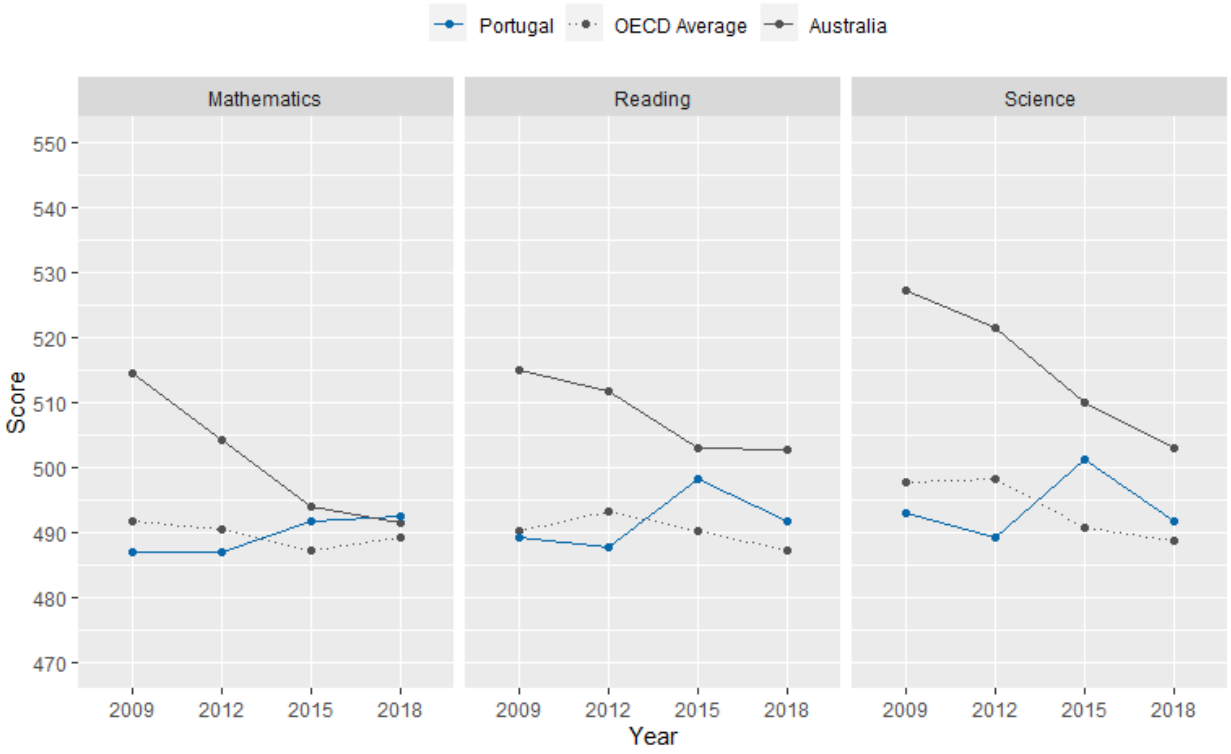

Figure 9. Average overall mathematics, reading, and science scores for 15-years-old students in Portugal

A.9.1 Digitalisation Programme for Schools

Portugal has been running a 'Digitalisation Programme for Schools', with professional development as the central area of focus (OECD, 2021a). This program includes the provision of training to upskill teachers' digital competency. The training focuses on using digital technologies for teaching and learning in all areas of the curriculum. Portugal also introduced communities of practice for teacher trainers to promote peer learning (OECD, 2021a). This initiative was supported by General Directorate of Education of the Ministry of Science and Education of Portugal. It is called 'Future Classroom Labs' and the aim is to build communities of practice for pre-service and in-service teachers. These learning labs allow teachers to reflect on the impact of new digital technologies on teaching and learning and to develop their digital literacy. The introduction of these learning labs has benefited teachers and students in several ways: Teachers have been using more collaborative inquiry-based and project-based pedagogies; they have been using more digital technologies in their classrooms; and students have been more actively engaged in the learning process (European Schoolnet, 2019a). The University of Lisbon is currently collecting data about the success of this project (European Schoolnet, 2019b)

A.9.2 First Cycle Primary School Programming Initiative

From 2015 to 2017, the Portuguese General Directorate of Education (DGE) promoted the pilot project 'First Cycle Primary School Programming Initiative'. This project aimed to contribute to

developing the capacities associated with computational thinking and digital literacy, and to foster cross-curricular competencies. The project's goal was to reinforce students' ICT skills and to help students improve their reading, comprehension, expression and writing skills, knowledge of mathematics, science, music, art, and other knowledge domains. The project also focused on generating ideas, encouraging students to be creative, and fostering collaboration and problem solving whilst increasing student motivation. Since 2015, Portugal has introduced 'Projeto GEN10S', a project that promotes programming skills for young people and equal opportunities in the digital area, reducing socio-economic and gender barriers. 'Providing equal opportunities to learn digital skills at school could help to reduce socio-economic disparities in emergent aspects of reading, such as distinguishing facts from opinions' (OECD, 2021a).

A.9.3 Addressing the first and second digital divides

Between 2000 and 2008, Portugal developed a technology plan for education with significant public investment, equipping schools with internet access and classrooms with computers and interactive boards. The government also supported the purchase of computers and tablets for students in elementary and secondary schools. Overall, the public and private investment on this project amounted to nearly AUD 4.8 billion. Following this national project, the private companies that supplied equipment and platforms formed a consortium designed to develop technologies in order to answer the schools' needs. This consortium developed the EduLab Project (2014-2017), with pilot classes in schools involving approximately 2000 students and 250 teachers. The aim of EduLab was to promote the development of digital literacy, knowledge and competencies of teachers and students by creating classrooms equipped with modern educational and technological resources (Oliveria & Pombo, 2016). It followed a new pedagogical model through which teachers and students could work with digital tools, in active classes with high level of participation of students working in groups or individually, inside and outside of the classroom, and offering continuous monitoring of students. EduLabs prioritised pedagogies and the technology was only used as a tool. In this model, schools had computers, interactive boards, Wi-Fi internet; and students had tablets, digital books and access to learning support platforms. Students and teachers were permanently connected by the platforms that support teaching and learning. Surveys were conducted in pilot schools and showed that students in Years 2, 5 and 8 enjoyed using the technologies and there was an improvement of 30% to 40% in students' performance compared to traditional teaching (Oliveria & Pombo, 2016; Sousa, 2017). Teachers also reported that technology had a positive impact on students' interest, motivation, participation and their autonomous learning (Oliveria & Pombo, 2016).

A.10 Qatar

Schools in Qatar are overseen by the Supreme Education Council (SEC), offering education in Arabic free of charge and split into three different levels: primary (6 to 12 years), preparatory (13 to 15 years) and secondary (16 to18 years). Government schools are extremely difficult to access for foreigners, who represent 88% of the population in Qatar. As a result, there is a large number of international schools with strong autonomy over their curricula.

Qatar's PISA results (Figure 10) are well below OECD average, however, with a rapidly increasing trend across all three categories (OECD, 2020a). When it comes to digitalisation of Qatar's society, the most important government document, 'Qatar National Vision 2030' (General Secretariat for Development Planning, 2008), does not provide any details around digitalisation of Qatar's education sector. Instead, there are several different government initiatives around the digitalisation of Qatar, some closely related to education, such as e-Education initiative (ictQATAR, 2007).

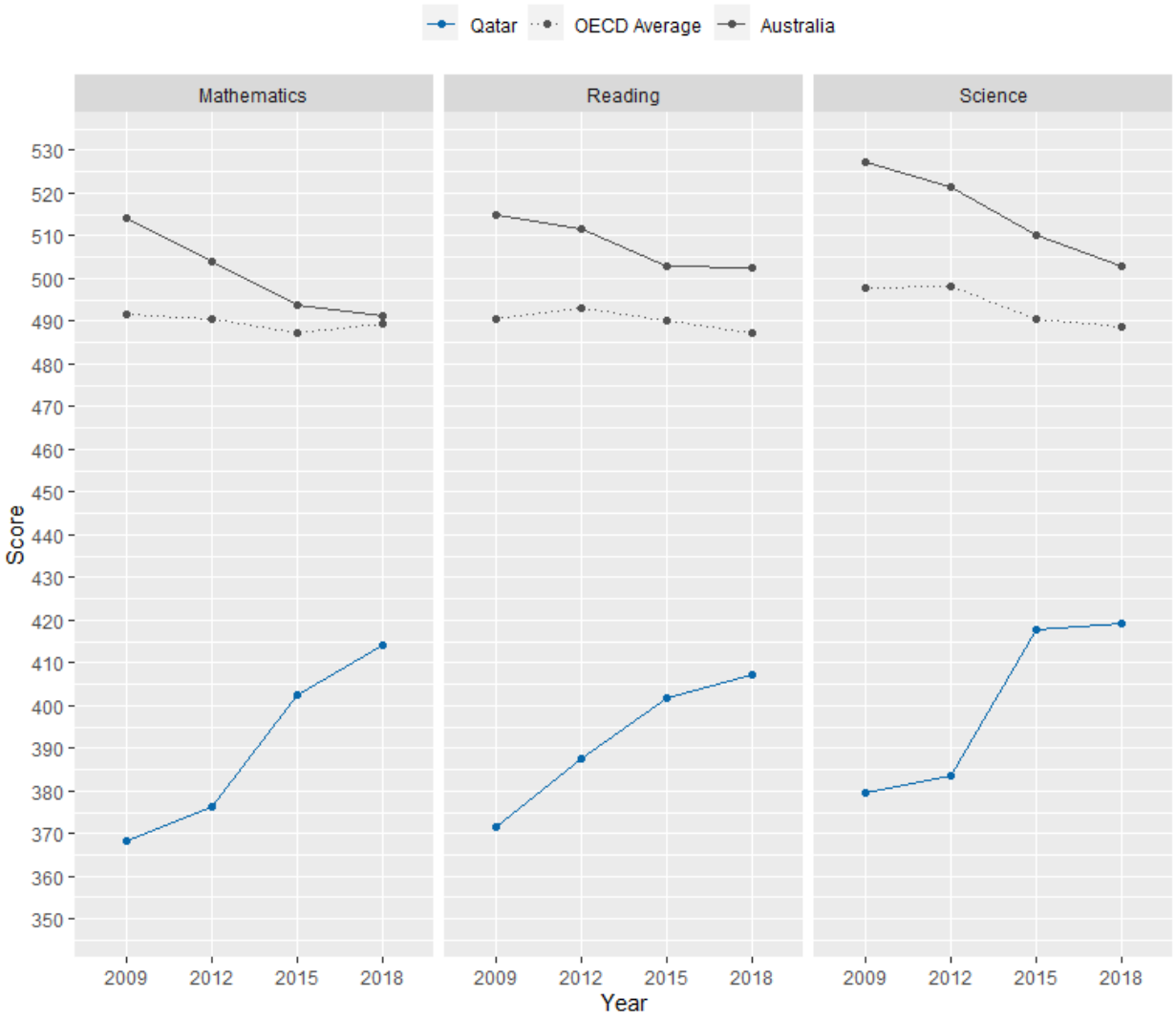

Figure 10. Average overall mathematics, reading, and science scores for 15-years-old students in Qatar

A.10.1 New Qatari Digital Government Strategy 2021–2026

In March 2021, the Qatari Government announced new 'Digital Government Strategy' for 2021–2026 (Road2Qatar, 2021). The strategy focuses on making use of the current advances in the digital government domain, as well as in four specialised domains: artificial intelligence, blockchain,

smart digital devices, and innovative applications for various aspects of human life. According to the Qatar Ministry of Transport and Communications, the new strategy will focus on services provided to individuals, supported by cloud-based infrastructure (Road2Qatar, 2021). While the details of the strategy and its impact on the education system are still not known, the 2021–2026 strategy is expanding on the two previous strategies, from 2014 and 2020, respectively.

A.10.2 ictQATAR

Founded by the Supreme Education Council, ictQATAR (Ministry of Information and Communications Technology) is the Qatar Government's strategic advisor in relation to ICT use in education, tasked with the design and delivery of Qatar's e-Education strategy. Overall, e-education goals focus on enhancing the student learning experience through ICT and improving overall productivity and quality of life through ICT (ictQATAR, 2007). Overall, the e-Education initiative focuses on supporting schools and teachers in adopting ICTs and developing innovative pedagogical approaches, as well as supporting students' self-directed learning, motivation, and academic achievement. The progress of schools is tracked along the five levels of e-Education development (ictQATAR, 2007):

1. *ICT-disabled school:* Poor ICT infrastructure, no plan, poor utilisation, mainly for e-literacy.
2. *ICT-supplied school:* Adequate ICT supplies, no plan, random utilisation, mostly experimentations and ICT literacy.
3. *ICT-enabled school:* Adequate infrastructure, tentative plan, discrete projects, partial solutions; ICT perceived and used as an add-on, no system integration. The goal of ICT is to enrich students' experience.
4. *ICT-integrated school:* Integrated system, systematic use, comprehensive solutions, integrated and complete plan; ICT mediates learning, instruction, communication, and effectively used for management, development. The goal of ICT is to improve students' and teachers' performance.
5. *ICT-advanced school:* ICT is woven into the school's fabric. In addition to stage 4, ICT is used more creatively to transform how school conducts learning, communication, and management. An ICT-advanced school is or seeks to be ICT-accredited.

The implementation of the e-Education strategy will address five dimensions (ictQATAR, 2007):

1. *Infrastructure:* Providing computers and connectivity to support teaching and learning at schools. Specific objectives include:
    a. Connect schools with broadband connections and networking capabilities (such as Wi-Fi).
    b. Create a 1:1 ratio of user to PC by providing every teacher and student with a computer through purchase and/or loan programs.

c. Equip classrooms with smart devices such as interactive whiteboards and voice-enabled applications.

d. Increase internet connectivity in Qatari households.

2. *Learning and Curriculum:* Teaching of ICT should be aligned with the adoption of new pedagogical approaches and e-learning content. Specific objectives include:

    a. Develop in-house digital forms of content and reference for all grade levels.

    b. Continue to grow online classes.

    c. Develop grade-appropriate curriculum standards addressing.

    d. ICT skills for K–12 students.

    e. Develop an academic path for students interested in ICT careers.

    f. Create a cadre of ICT teachers and professors.

3. *ICT Tools and Utilisation:* Developing tools and resources to support teaching and learning processes. Specific objectives are:

    a. Develop a content management system that international institutions can share and collaborate on.

    b. Develop an e-Education nationwide portal.

    c. Use education information systems to increase the efficiency of the school administrations.

4. *Professional Development (PD):* Provide teacher-focused PD as a way of improving their digital literacy. Objectives include:

    a. Offer more ICT workshops that help teachers teach, learn, communicate, and reduce their administrative workload.

    b. Create an ICT competency certificate for teachers and administrators.

5. *e-Education Plans:* Provide support to schools in developing their own e-Education strategies and operational plans. The specific objective includes developing an e-Education tool for assessment and planning that includes timelines, resources, competences, incentives, and benchmarks.

A.10.3 Addressing the first digital divide

In Qatar, although there is no education-specific inclusion plan or strategy, there are significant efforts to address challenges of digital inclusion. With Qatar's National Vision 2030 (General Secretariat for Development Planning, 2008) to transform Qatar to a knowledge-based economy, the National ICT Plan set the target of 90% of the population adopting ICTs by 2015, given the essential role of ICT in this process (Iqbal & Radcliffe, 2013). While there have not been official

updates on reaching this target, in 2020, World Economic Forum ranked Qatar ninth in the world for ICT adoption and second in Arab world (behind the United Arab Emirates), with 83.9% of target population (four years and over) using ICT (Schwab & Zahidi, 2020). More recently, the Tasmu Smart Qatar Programme has been established by the Ministry of Transport and Communications to tackle digital inclusion, including digital skills, access, motivation and trust (Gulftimes, 2020).

A.11 Scotland, UK

The Scottish Government is the central education authority and governs education policy. Local authorities are responsible for schools, hiring school staff, providing and financing most educational services, and implementing Scottish Government policies in education. Scotland has consistently been performing above OECD level in PISA assessments, but there has been a decline in performance in mathematics and science over the last two cycles (OECD, 2020a) (see Figure 11).

Scotland has a dedicated Digital Education Strategy, which was launched in 2016, as well as a more general Updated Digital Strategy for Scotland, which was published in 2021. These strategies will ensure that digital capability plays a key role in education to assist in establishing a strong, digitally skilled workforce. In order to embed the use of digital technology in education, a number of key objectives have been identified to support this. These include:

- Develop the skills and confidence of educators in the appropriate and effective use of digital technology to support learning and teaching.
- Improve access to digital technology for all learners.
- Ensure that digital technology is a central consideration in all areas of curriculum and assessment delivery.
- Empower leaders of change to drive innovation and investment in digital technology for learning and teaching. (Scottish Government, 2016)

Figure 11. Average overall mathematics, reading, and science scores for 15-years-old students in Scotland

A.11.1 Teacher training within the 'Glow' digital platform

The Scottish Digital Learning and Teaching Strategy has a strong focus on teacher training, supported by the national 'Glow' digital platform. Glow, the Scottish national schools' intranet, was launched in 2009 and redeveloped in 2014 to become an entirely cloud-based service. Glow provides professional learning communities for teachers, and a platform to share digital resources, as exemplified by the National Numeracy and Mathematics Hub (OECD, 2021a). One of the main benefits of Glow is that it is available to all schools in Scotland, and the integrated video conferencing function can reach teachers who work in remote and rural areas.

A.11.2 Addressing the first digital divide

Scotland has also addressed the first digital divide through their Digital Learning and Teaching Strategy. This strategy was launched in 2016 to improve access to ICT for students. This initiative is not funded at the national level; local authorities are responsible for funding improvements. For example, in 2018, the Glasgow City Council expanded the Wi-Fi availability to classrooms, increased internet speeds, and implemented a 1:1 device initiative for all students and educational staff. This project involved distributing 55,000 iPads to primary and secondary school children in Glasgow through the Connected Learning programme. Additionally, 3,600 Wi-Fi hotspots and Apple TVs have been installed in schools to allow teachers and students to project to digital screens wirelessly. This initiative was part of a close collaboration between national agencies and suppliers (Burns & Gottschalk, 2019), but no data on its effectiveness has been published yet.

A.12 Singapore

In Singapore, the education system begins with six years of primary school, then four to six years of secondary school, and finally one to three years of postsecondary school. Students in primary school all study the same curriculum. For Years 5 and 6, students can choose to take courses at the foundation or standard level. Foundational level courses provide more support for students. Upon entering secondary school, a collective decision is made between students, teachers and their parents to determine what 'stream' the student will pursue. These streams are either Express, Normal (Academic), or Normal (Technical). All streams offer the same course of study, but Express is accelerated and Normal (Technical) offers more applied work. Singaporean students ranked first in PISA scores for reading, mathematics and science in 2015 (see Figure 12). Supporting students' self-directed learning is a key component of Singapore's ICT masterplans, and technology is a core feature of their vision. Singapore consistently reports very high PISA scores in mathematics and is above average for both reading and science (OECD, 2020a).

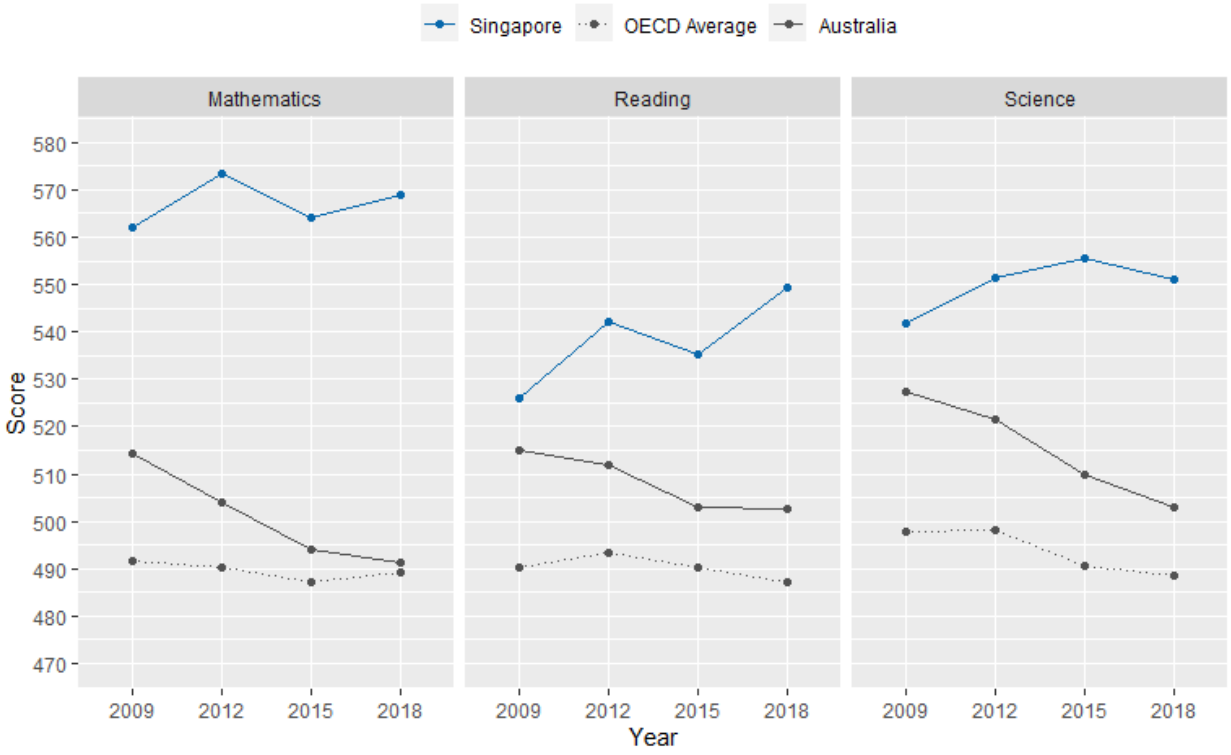

Figure 12. average overall mathematics, reading, and science scores for 15-years-old students in Singapore

A.12.1 Cyber Wellness project

Cyber Wellness (CW) in Character and Citizenship Education (CCE) focuses on the wellbeing of students in Singapore as they navigate cyberspace. Their curriculum aims to support students to develop the knowledge and skills to use ICT for positive purposes, maintain a positive presence in

cyberspace and be safe users of ICT. There are three main principles guiding children's decision-making and anchoring their wellbeing:

- Respect for self and others.
- Safe and responsible use.
- Positive peer influence.

Cyber wellness education is run through workshops and during class time in both English and mother tongue languages.

A.12.2 Singapore and AI

The Singapore Government has a commitment to developing their AI strategy for the nation. Their latest plan is to transform the economy, to fundamentally rethink business models and to generate change. Within education, the plan is to provide personalised education through adaptive learning and assessment. The government predicts this approach to education will reap the following benefits:

- Students will have a more personalised learning experience, tailored to their individual strengths and weaknesses.
- Teachers will spend less time on routine assessment tasks and can guide students' learning more effectively through data-driven insights.
- In the long run, students of diverse learning needs, as well as low-progress learners, will be better supported, raising their achievement level.

The government will begin piloting this program in 2022.

A.13 Slovenia

Governance of the Slovenian education system is mainly shared between the central government and schools. Slovenia has an integrated pre-school system of early childhood education and care and pre-primary education for children aged one to six. Compulsory basic education is organised into a comprehensive structure called basic school and is attended by students aged six to fifteen. Slovenia's educational performance in PISA 2012 was above the OECD average in mathematics and science, but below average in reading. Results improved in reading in mathematics in PISA 2018 but declined slightly in science (OECD, 2020a) (see Figure 13).

Slovenia does not have a specific digital education strategy, but a generic digital strategy called 'Digital Slovenia 2020', which is a framework for faster development of the digital society and the use of opportunities enabled by ICT and the internet for general economic and social benefits (Government of the Republic of Slovenia, 2016).

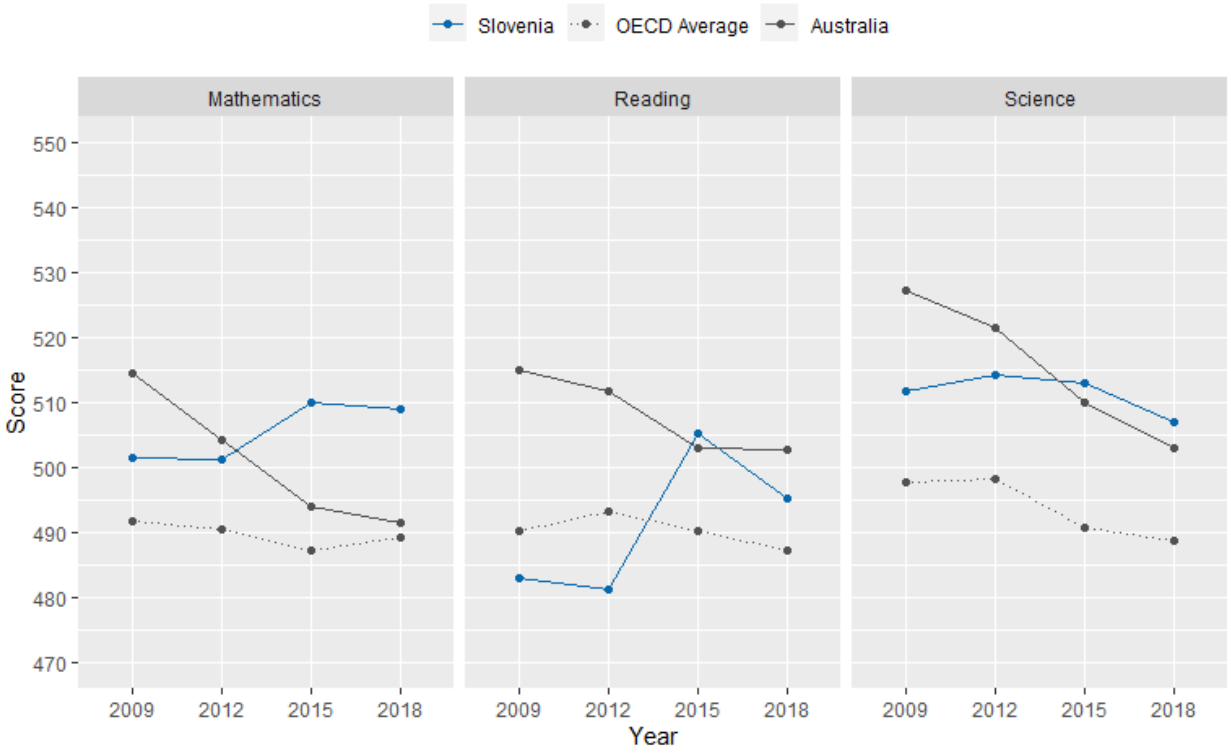

Figure 13. Average overall mathematics, reading, and science scores for 15-years-old students in Slovenia

A.13.1 E-Education project

The Slovenian Ministry of Education, Science and Sports implemented the national E-Education Project (2009-2014) with the overall aim of building a pathway for schools to prepare for modern technologies and become e-competent (Conrads et al., 2017). This project included teacher training, and the development of e-competence standards for schools and teachers. It also facilitated access to learning content and online services, including new communication platforms. This project used a seminar format whereby teachers engaged in workshops that supported their digital competency across 20 subject areas. By providing such a broad range of subject areas, teachers were enabled to develop authentic e-competences that were directly transferable into practice. 99% of educational institutions in Slovenia participated in the project. The project was very well accepted among schools, teachers and ICT coordinators, and successfully upskilled teachers in Slovenia with some teachers taking part in more than one seminar (Conrads et al., 2017). After the E-Education ended, new projects were designed to continue the initiative through which students and teachers were encouraged to try different digital-based pedagogies and infrastructures.

A.13.2 Addressing the first digital divide

In 2017, Slovenia implemented the 'Strategic Guidelines for Further Implementation of ICT in Slovenian Education until 2020', based on the National Strategy for the Development of

Information Society until 2020. This strategy defined the common vision, goals and principles for further ICT implementation in Slovenian schools between 2017 and 2020, and referred to didactics and e-material, platforms and co-operation, e-competencies, informatisation of institutions, e-education (higher education, adult education) and system evaluation (MIZS, 2016).

A.13.3 Addressing the second digital divide

The Opening up Slovenia Initiative was launched in 2015 and aimed to complement existing education practices with innovative, dynamic and open learning approaches. This framework focuses on digital competences (of learners, teachers and citizens) as a route to digital transformation, and aims to make changes to education in seven target areas:

> 1) transform existing educational methods into innovative, dynamic and open learning tools; 2) restore an environment of co-operation between public, private and voluntary sectors of research; 3) develop and introduce a more open education; 4) build legal mechanisms in support of implementing open education; 5) construct an open platform of information technologies, contents, services, pedagogical concepts and approaches; 6) restore mechanisms for securing a high level of quality and evaluation of services; 7) develop digital competencies within the entire educational system, and carry out concrete, cross-dimensional open education projects. (OUSlovenia, 2018)

A.13.4 Privacy, security and safety

'Safer Internet Centre Slovenia' is a national project co-financed by the European Union's Connecting Europe Facility, which promotes and ensures a safer internet for children (Better Internet for Kids, 2021). The project is run by a consortium of partners coordinated by the Faculty of Social Sciences at the University of Ljubljana, Academic and Research Network of Slovenia, the Slovenian Association of Friends of Youth, and the Youth Information and Counselling Center of Slovenia. 'Safer Internet Centre Slovenia' has three components:

1. An awareness centre (www.safe.si), which raises awareness of children, adolescents, parents, teachers, youth and social workers about safe and responsible use of the internet and new technologies.
2. A toll-free helpline, TOM telephon for young people and their parents who find themselves in internet-related trouble (including a chat and e-mail).
3. A hotline, Spletno oko, for anonymous reporting of illegal online content, such as child abuse material online and hate speech (www.spletno-oko.si).

A.14 South Korea

The South Korean public education system is composed of three parts: six years of primary school, then three years of middle school followed by three years of high school. In 1996 only about 5% of Korea's high schools were coeducational. Since then? the proportion of coeducational schools

has increased by almost 10%. However, classes in many coeducational high schools are still divided along gender lines. The curriculum is standardised so now both boys and girls study technology and domestic science.

The South Korean education system produces strong PISA results. Ed-tech has been strongly supported by the government for over 30 years and constitutes a large part of the government's reform strategies to focus on developing students' 21st century skills and using the latest cutting-edge technology. South Korea has mixed PISA results. Whilst all scores are above average there is variability amongst their mathematics, reading and science PISA scores. However, 2018 results highlight an increasing trend in PISA scores (OECD, 2020a) (see Figure 14)

Figure 14. Average overall mathematics, reading, and science scores for 15-years-old students in South Korea

A.14.1 First digital divide

There is a high level of technology coverage in South Korea. According to the 2017 Measuring the Information Society Report[6], Korea ranked second worldwide in terms of technology access (ICT infrastructure), level of ICT usage, and the level of ICT skills in the general population

[6] https://www.oecd-ilibrary.org/content/publication/pub-80f52533-en

(usage). The report is a leading publication broadly recognised as world's most reliable and impartial global analysis of ICT development across the globe.

A.14.2 Cyber security

The Cybersmile Foundation has made its entire online curriculum free to access for all schools, colleges, universities and institutions. The education program is made up of more than 80 workshops and was developed by Cybersmile and a panel of experts across a variety of fields including psychology, teaching, information technology and parenting.

Appendix B: Maturity index of individual country summaries

Table 1 compares system-level policies and practices of the countries included in this report to tackle the digital divides. It includes a summary of each country's approach to digital technologies and can be used to gauge how developed or 'mature' each nation is regarding embedding digital technologies into their education policies. This information has been adapted from the OECD 21st Century Children report (Burns & Gottschalk, 2019).

Table 1: System-level policies practices: Country summaries

Australia (NSW)

First digital divide: The Australian Digital Inclusion Index score for NSW is 63.5 (SA is 61.9, and Australia is 63).[7] However, in 2020, households in the lowest-income quintile had a digital inclusion score of 43.8, which is 30.0 points lower than those in highest income quintile (73.8). Further, in 2020, digital inclusion was 7.6 points higher in capital cities (65.0) than in rural areas (57.4), and although internet infrastructure is available to almost all Australians, more than 2.5 million remain offline (Thomas et al., 2020). The NSW Digital Strategy for Schools aims to build schools' digital equity, experience and capability by strengthening digital foundations, improving device access ratios, and raising the quality and availability of digital resources (NSW Department of Education, 2019).

Second digital divide/developing digital competencies: The NSW Digital Strategy for Schools aims to deliver effective digital support through a service model that provides training, guidance and direct assistance in integrating digital tools and techniques, and empowers schools to shape their digital journey by providing resources to help them assess and understand their digital maturity (NSW Department of Education, 2019).

Integration of digital technologies into teaching and learning: NSW has a digital technologies hub, where the provision of learning resources and activities helps to support the implementation of the curriculum. NSW invests in enhancing data analytics and reporting through the development of advanced analytics. The evolution of the Centre for Education Statistics and Evaluation (CESE) into a data and analytics centre of excellence, to integrate data within and beyond schools, facilitates comprehensive student data gathering (NSW Department of Education, 2019). Advanced analytics underpin many strategy components, including personalised learning support, welfare support, and enhanced performance understanding (NSW Department of Education, 2019). The NSW government integrates digital learning into personalised learning to support students with high needs (NSW Department of Education, 2019).

Maturity indication of country development: While Australia has done much, and continues to so, in closing the digital divides in schools, it should be considered that, with the rising necessity of schooling from home due to COVID-19, the first digital divide remains a concern for some students.

Estonia

First digital divide: Since 2000, every school in Estonia has had digital classes and every classroom has had access to a computer.

Second digital divide/developing digital competencies: In 2014, Estonia introduced a lifelong learning strategy. The idea of the programme is to help develop the digital competencies of both teachers and students. IT-training courses and instructional materials have helped to integrate digital technology into the learning process in order to develop digital competence.

[7] The Australian Digital Inclusion Index measures three key dimensions of digital inclusion: Access, Affordability, and Digital Ability (digitalinclusionindex.org.au)

Estonia, cont ...

Integration of digital technologies into teaching and learning: Estonia had an established online platform to support student learning prior to COVID-19 and therefore Estonia (alongside Singapore) led the way in supporting other countries to go digital. They also shared all of their digital education tools with other countries for free.

Maturity indication of country development: The Estonian government credits the success of the digital transformation of the Estonian education system to their thorough professional development and training of teachers and educational technologists

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Finland

First digital divide: In 2009, the Finnish government became the first in the world to make broadband internet access a legal right. Despite this, only 21% of teachers feel prepared to use ICT in their teaching (OECD 2021), suggesting more effort should be placed into teacher professional development.

Second digital divide/developing digital competencies: Finland has a strong focus on making digital technologies more accessible for those living with disability. A recent report suggests that providing smart devices for those living with disability may lessen this gap (Tuikka, Vesala, & Teittinen, 2018).

Integration of digital technologies into teaching and learning: Online learning platforms and individualised learning pathways are being adopted across the nation to support individual student choices (Ministry for Foreign Affairs, Department for Communications, 2021).

Maturity indication of country development: More emphasis should be placed on teacher professional development to ensure this new wave of online individual learning plans reach their full potential. This has been a problem since the early 2000s.

Germany

First digital divide: While the majority of German teenagers have mobile phones, the number drops below 50% for children between 6 and 12 years. The rate of laptop ownership is significantly lower, ranging between 25% and 67% (Blume, 2020). While more than 90% of Germans have internet, the speed and quality of the connection in rural areas is often inadequate, either because of prohibiting costs or lack of infrastructure.

Second digital divide/developing digital competencies: According to Blume (2020), German teachers have been much more reluctant to integrate digital technologies compared to similarly developed countries. While the international average of teachers who include digital technologies was 78.2%, in Germany it was only around 60.2% (Blume, 2020). The big focus of the Digital Pact for School has been provision of devices and training to teachers, who often lack digital competencies and perceive that as a threat to their authority as teachers. According to Bockermann (2014), over 40% of pre-service teachers anticipate that their students know more about digital technologies than their teachers.

Integration of digital technologies into teaching and learning: The 2016 Education in the Digital World strategy sets the goal that by 2021 every student should be able to use the digital learning environment and have access to the internet wherever it is deemed useful for pedagogical purposes (KMK, 2016).

Maturity indication of country development: Primary focus is on developing teacher's competencies and providing access to internet and devices in rural areas, where costs and infrastructure are still prohibiting productive use of internet technologies for learning purposes.

Ireland

First digital divide: A 2019 review of Ireland's digital strategy highlighted that digital learning technologies were used in 55% of lessons observed in primary schools and 62% of lessons observed in post-primary schools.

Second digital divide/developing digital competencies: Ireland's Department of Education 2019-2021 strategy aims to advance the progress of learners at risk of educational disadvantage and learners with special educational needs to support them to achieve their potential (Ireland Department of Education and Skills, 2020). To achieve the goal, the government has committed to (1) Implement the Delivering Equality of Opportunity in Schools action plan to close the gap in performance and increase retention rates; (2) Explore innovative approaches to improving the outcomes for learners at greatest risk of educational disadvantage; (3) Progress the implementation of a school inclusion model to deliver the right supports at the right time to students with additional care needs; (4) Further progress the move towards a needs-based, responsive set of State supports for students with special educational needs, focusing on improved measurable outcomes; and (5) Implement strands of the National Access Plan to ensure that the student body in higher education reflects the diversity of Ireland's population.

Integration of digital technologies into teaching and learning: The 'Teaching, Learning and Assessment Using ICT' theme aimed to embed ICT into the education system at all levels. The strategy provided advice and guidance for teachers and schools that included good practice on ICT use. The UNESCO ICT competency framework was used for teachers (adapted to meet the Irish context) to provide support materials and services to schools on embedding ICT into practice. Ireland has implemented three Skills Action Plan reforms, the most recent in 2019. The recently concluded 2014-2018 Action Plan included provisions for promoting career opportunities to primary and secondary level students, involved curricular reform, and provision of ICT-related professional development opportunities for teachers. There is a focus on upskilling teachers with the knowledge, skills, and confidence to integrate ICT into practice. This theme was partly addressed through embedding ICT for teaching at each stage of the teacher education continuum.

Maturity indication of country development: Ireland has focused on ICT in education in many of its strategies addressing the digital divide.

Japan

First digital divide: In 2019, the Japanese Ministry of Education, Culture, Sports, Science and Technology (MEXT) launched the Global Innovation Gateway for All (GIGA) initiative that allows local boards of education to provide a device for each student with a high-speed network in Grades 1 to 9. Additionally, each student will receive a top up to support the device's purchase.

Second digital divide/developing digital competencies: The development of digital competencies has been identified as an area in need of improvement (OECD, 2018). The OECD Survey of Adult Skills (2013) found that Japanese young people aged 16-24 did not perform as well as their international peers in their ability to solve problems in technology-rich environments. Out of school hours, Japanese students have the lowest use of ICT for homework, and the second-lowest use of ICT at school after Korean students (OECD, 2015).

Integration of digital technologies into teaching and learning: MEXT is currently building an ICT system for education. They are 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 (MEXT, 2020).

Maturity indication of country development: Japan has been slow to introduce ICT in education (OECD, 2019).

Qatar

First digital divide: Qatar's National Vision 2030 has a strong focus on digital inclusion and has set a target of 90% ICT adoption rate by 2015 (Iqbal & Radcliffe, 2013). In 2020, a new inclusive digital strategy was announced (Gulftimes, 2020), which outlines four key directions for next five years:

1. Access to the Internet, smart devices and e-payment systems
2. Basic digital skills for operating digital devices and tools
3. Motivation for understanding the benefits of digital services
4. Trust in using digital tools and services.

Second digital divide/developing digital competencies: The Qatar Government has developed a digital Unified Student Record, to streamline administrative processes for both students and school staff. ictQATAR is assisting the implementation of the initiative as well as implementation of different school learning systems to support school data management (ictQATAR, 2007).

Integration of digital technologies into teaching and learning:

The Qatar Government recognises the need for developing skills for critical and effective use of digital systems. Their approach in this domain focuses on four key components to bring groups that have been marginalised and lack motivation and skills to effectively use digital tools

1. Collaborating with local organisations that work with digitally excluded groups
2. Taking account of local cultural and religious issues
3. Contextualising training and awareness raising initiatives
4. Reflecting the digital literacy levels and language needs for the different target groups

Maturity indication of country development: The focus of digitalisation initiatives has been mainly on non-working Qatari woman, the elderly, and rural communities, with particular care for respecting religions and cultural norms.

Scotland (UK)

First digital divide: Scotland has addressed this divide through their Digital Learning and Teaching Strategy, which was launched in 2016 to improve access to ICT for students. According to PISA 2018, only 57.4% of students were in schools whose principal agreed or strongly agreed that the number of digital devices connected to the internet is sufficient.

Second digital divide/developing digital competencies: According to PISA 2018, 68.7% of students were in schools whose principal agreed or strongly agreed that teachers have the necessary technical and pedagogical skills to integrate digital devices in instruction. Developing the skills and confidence of educators in the appropriate and effective use of digital technology to support learning and teaching is one of the key goals of Scotland's digital strategy.

Integration of digital technologies into teaching and learning: Digital technology is embedded within Scottish education, in the Curriculum for Excellence, Initial Teacher Education and the Professional Standards set by the General Teaching Council for Scotland.

Maturity indication of country development: The four objectives of the Digital Learning and Teaching Strategy for Scotland are to:

1. Develop the skills and confidence of educators in the appropriate and effective use of digital technology to support learning and teaching
2. Improve access to digital technology for all learners
3. Ensure that digital technology is a central consideration in all areas of curriculum and assessment delivery
4. Empower leaders of change to drive innovation and investment in digital technology for learning and teaching (Scottish Government, 2016, p. 3).

Singapore

First digital divide: From 2020, Singapore has adopted a personal learning device (PLD) initiative that will progressively roll out PLD to all secondary students. They ramped up the program because of COVID-19.

Second digital divide/developing digital competencies: In 2020, the government adopted policies that allow teachers to take a sabbatical to focus on external workplace attachments in the hope that teachers will increase their digital skills.

Integration of digital technologies into teaching and learning: Singapore has a strong experimental and data-driven curriculum. They favour online learning and use learning analytics to support their teachers and students. Alongside Estonia, Singapore was already completing education online before COVID-19 and did not struggle with the transition.

Maturity indication of country development: Singapore is later than most countries to ensure each student has access to devices. However, they are leading the way in AI and data-driven solutions. Once their digital divide is lessened, they are predicted to be a powerhouse in digital education.

Slovenia

First digital divide: Slovenian schools are better connected and digitally equipped than the European average, particularly for high-speed connectivity (70% of upper secondary schools compared to 18% of schools in the EU; European Commission, 2019b). However, connectivity remains low in remote areas. Interestingly, PISA results showed that Slovenia students report one of the lowest rates of ICT availability at school (European Commission, 2019b). There are national policies to support investments in schools' digital infrastructure and digital learning resources, but few schools have dedicated ICT strategies, even though there are ICT coordinators in primary schools (European Commission, 2019b).

Second digital divide/developing digital competencies: In 2007, Slovenia adopted the 'Development Strategy for the Information Society until 2017' (Brecko & Vehovar, 2008), which included plans for increasing ICT integration into school curricula. This, in turn, raises the level of ICT skills and knowledge by individual users. In Slovenia's development strategy 2014–2020, digital literacy was described as being 'of primary importance', as 'only digitally literate individuals will easily and equally integrate into the information society' (Ministrstvo za gospodarski razvoj in tehnologijo, 2013).

Integration of digital technologies into teaching and learning: Slovenia created digital teaching materials in 2005-2015 (Pesek et al., 2014). They have networks for the exchange of good practice available on their i-ecosystem webpage, and good infrastructure.

Maturity indication of country development: Digital skills are integrated into school education. The digital skills of Slovenian students are better than the European average (European Commission, 2019b). Initiatives such as Opening Up Slovenia support the digital transformation of the country.

South Korea

First digital divide: All content of South Korea's school subjects has been available on PCs, iPads and mobile phones since 2015.

Second digital divide/developing digital competencies: Since 2005, all children have received classes on ICT.

Integration of digital technologies into teaching and learning: South Korea is moving towards a learning analytics and AI focus and is putting all middle school textbooks online

Maturity indication of country development: There is a strong infrastructure focus, and a desire to move towards lifelong learning for all with a strong digital focus.

Centre for Change and Complexity in Learning

The Centre for Change and Complexity in Learning (C3L) focuses on human and artificial cognition, knowledge processes, and teaching and learning in digital settings. Our innovative research in learning analytics and AI in education and training is world leading. C3L is home to academics and researchers who are recognised as global leaders in implementing and evaluating new technologies and pedagogies to enable future learning models and assist organisations with digital transformations in learning and development. C3L is at the forefront of the most significant educational trends of the past several decades: digital learning, learning analytics, MOOCs, networked and distributed learning, and AI in education. More than 50 academics call C3L their home, representing education, cognitive psychology, computer science, health, and engineering. The Centre is actively engaged in projects and collaborations with top universities, government agencies, and corporations from around the world.

C3L focuses on four distinct areas of change:

- Social and learning analytics: focuses on how data can support our understanding of learning and guide leaders in their decision-making processes.
- Infrastructure for AI: focuses on the technology infrastructure needed for implementing real-time assessment and feedback for personalised learning.
- Human and Artificial Cognition: researches how humans and artificial agents interact in knowledge work
- Complexity leadership and systems change: focuses on how leaders support and enable organisational innovation.