Use of Digital Technology in Education: Literature Review

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Executive Summary

This report has been prepared to assist in shaping the South Australian Department for Education's new digital strategy. It focuses on a review of academic literature and draws on extensive research to detail the use and impact of digital technology in education. The review features examples of how digital technology is used to enable effective learning outcomes, assist system improvements, and how these systems can support teachers.

There is a strong consensus that digital technology can improve teaching and learning by motivating students with engaging, interactive, and fun learning environments. For example, digital technology offers new avenues of meaningful communication and collaboration between teachers and students. Integrating into classroom practice communicative digital tools, such as online forums and digital storytelling, enables core academic learning to be expressed and explored via multimedia conversations and exchanges. Moreover, digital technology can open dialogue between various cultures and countries to promote purposeful intercultural communication and collaboration. In turn, these online interactions create further opportunities to develop digital literacy, 21st century skills, and digital citizenship.

Digital technology also opens immersive educational spaces, giving students novel learning opportunities. Interactive digital tools, such as problem-solving games, modelling software and 3D printing, support cognitive development and allow students to understand abstract concepts, visualise virtual objects, and produce tangible artefacts. By engaging in dynamic digital environments, students can view and discuss key concepts from different perspectives.

Early childhood mathematics and language learning makes extensive use of digital tools, such as play-based maths, vocabulary and reading apps. Special education has benefited from apps on touch screen devices, as the interfaces allow for easy navigation, which in turn assists in bridging differential access to technology. Apps provide engaging, interactive, and fun learning spaces; they enable students to strengthen established knowledge by exploring meaningful applications of skills, strategies, and rules. However, teachers should maintain a central role by providing students with initial instruction, adequate scaffolding and formative feedback throughout app-assisted learning activities.

Schools use digital technology to inform student progress and learning outcomes and to optimise work procedures. Interconnected digital systems provide support across the entire education system. The use of integrated digital platforms and systems to deliver a steady data stream is increasing and helps to develop robust learning analytics. Data-driven decision making (DDDM) can be used systematically in organisations to detect learner differences, address personalised learning, and augment students' learning achievements. DDDM contributes to making informed decisions concerning student capabilities and implementing early initiatives for at-risk students or students with learning disabilities.

To achieve successful digital technology adoption and integration, teachers need sufficient support and professional development. The main barriers to effective technology use in the classroom include a lack of time, incentive, technological assistance, and not knowing how to implement technology in a practical manner (Fransson et al., 2020; Hill & Valdez-Garcia,

2020). Providing innovative professional development, which engages teachers in the design and execution process, builds knowledge and affords teachers agency and ownership in using digital technologies in their practice.

1. Introduction

Our future society will be dominated by artificial intelligence (AI) and advanced technology and automation, requiring the next generation of citizens entering the workforce to be technology savvy. This future, however, starts now, and ensuring high quality integration of technology in schools is required to help shape and build the digital society. According to UNESCO (2021), one of the main aims of education is to prepare future generations for this digital future, and to equip them to deal with the rapid development of technologies, cope with the continuous access to vast amounts of new knowledge and information, and foster critical thinking, sense-making, creativity and collaboration skills to excel in digital contexts. UNESCO emphasises the importance of governments and schools having a digital strategy that offers guidance on how to implement digital systems, technologies, digital learning design, and pedagogy and to benchmark performance against evidence-based criteria and conditions for success.

The current digital strategy of the Department for Education South Australia is at the end of its life cycle. Developing a new digital strategy presents an opportunity to recast technology from a targeted resource lever to 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. Similar to other educational transformation frameworks, such as Microsoft Educational Framework (2014), ISTE Essential Conditions (2016) and Haynes and Shelton (2018), the new strategy aims to guide a holistic change and draws on evidence to facilitate a well-structed and rigorous process.

The following literature review situates the use of digital technology in education within the context of research evidence. The guiding question for this literature review is:

- What does the academic literature tell us about the use of digital technologies for:
    - effective learning outcomes?
    - system improvements and teacher requirements for support?

The findings of this literature review 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.

2. Methodology

This review is limited to academic peer-reviewed journal articles published between 2016 and2021. The Education Resources Information Centre (ERIC) database, a widely used database specialising in indexing education research, was used to search for academic peer-reviewed journal articles focusing on technology use in pre-school (early learning), primary

and secondary education and the use of digital technology or systems to facilitate data-driven decision-making in schools. We included two search strings for each of the focus areas of the research question (learning outcomes, system improvements, teacher support), one addressing the use of digital technology, the other addressing data-driven decision making.

Search strings used in ERIC:

Search 1 - Learning Outcomes:

1a (digital technolog*) AND (learning outcomes)

1b (data-driven) AND (learning outcomes)

Search 2 - System Improvements:

2a (digital technolog*) AND (system improvement)

2b (data-driven) AND (system improvement)

Search 3 - Teacher Support

3a (digital technolog*) AND (teacher) AND (support)

3b (data-driven) AND (teacher) AND (support)

These searches returned a total of 333 articles that matched our criteria. These articles were evaluated to see if they address the questions of this review. To determine this, the inclusion and exclusion criteria in Table 1 were used. Based on this process 195 articles were excluded, resulting in a total of 138 articles to be considered for analysis. During the analysis process, some articles could not be located or were not peer-reviewed articles (excluding another 9 articles) or were found to be off topic (for example, the study was not actually on digital technology) and were excluded from the analysis as well (17 articles). As a result, a total of 112 articles were included in this review.

Table 1. Inclusion and exclusion criteria

Inclusion	**Exclusion**
2016 - 2021	before 2016
Empirical and review articles	Curriculum studies
Pre-school (early learning), primary, secondary	Higher Education, University, Vocational Education
Data-driven decision making	Non-digital data-driven decision making (teacher observations, standardised surveys)

2.1 Appraisal of the literature

Of the studies included, most were empirical studies (101) researching the use of digital technologies or data-driven approaches to education. Eight conceptual studies were included and three review articles. Further, the articles covered a broad range of different educational levels; 11 papers were in the domain of early learning, 44 were studies in primary education, 33 studies were at the secondary level, and 24 studies covered multiple educational levels.

Not all articles indicated the region or country where the study was carried out. Where regional location was indicated, we found that 8 studies were carried out in Australia or New Zealand, 14 were conducted in the US or Canada, 21 were situated in Europe, 15 in Asia, 5 in Africa or the Middle East, and 2 were based in South America.

Participant numbers included in the studies varied extensively. As a rough indication we found, 24 small studies (1-15 participants), 47 medium-size studies (N = 16-100), and 17 large studies (N > 100). Where indicated by the authors, 38 studies were qualitative, 25 were quantitative and 42 reported a mixed-method approach. Of the data collection methods discussed, interviews were the most widely used approach, followed by surveys and test scores, and then observations.

Our findings are presented in Sections 3 and 4.

3. Improved and enhanced teaching and learning

Digital technologies are used in education to provide engaging learning environments that inspire and motivate students to learn. They have long been heralded as a means for educational transformation. Various research has established connections between digital technologies and student engagement, motivation, and positive learning outcomes (Fokides & Kefallinou, 2020; Heindl & Nader, 2018; Kotsari & Smyrnaiou, 2017; Moyer et al., 2018). This involves opening classrooms to engage in connected learning and exploration beyond the boundaries of the school, and incorporating technologies into the curriculum to facilitate diverse and flexible delivery of content. Technology can also increase inclusivity, equity and social responsibility by providing a learning environment that inspires students and prepares them for a technology-focused society. The included empirical papers indicate the value of digital technologies mostly through teachers' perceptions and experiences working with these technologies. Just as there is a range of digital tools investigated, the contexts in which the studies are conducted are also quite diverse, providing insight into the ways that technology can be integrated into the curriculum to meet a variety of intended outcomes. The studies are predominantly focused on single use technologies in small to medium size studies. They may point to improved student learning outcomes, but it is difficult to infer or judge system-level implications. Below, we will present short illustrations of studies to highlight technology use and its impact on teaching and learning.

3.1 Communication and collaboration

The research shows that digital learning activities, which promote purposeful communication and collaboration amongst teachers and students, open greater opportunities to converse in creative and meaningful ways when compared to non-digital learning activities. Integrating communicative digital tools, into classroom practice such as Facebook and discussion forums, can support core learning areas and digital literacy across subjects, foster 21st century skills, and cultivate cultural awareness and digital citizenship.

For example, Buckley-Marudas (2016) examined online discussion forums to study multicultural teaching and learning in connection to race, language, class, and other identities salient to classroom communities. The research posits a pedagogical approach which contextualises multiculturalism within core learning areas, drawing upon digital media to cultivate culturally responsive education. In Year 10 English classes, topics related to language, identity and stereotypes were launched in a forum, and students were invited to share their ideas and opinions in an informal, yet respectful manner. The findings revealed that students became more democratic citizens. Rather than judging or disrespecting those who may be perceived as 'different', students developed a deeper appreciation of each other's differences and perspectives. They found that the online forum cultivated open, contrasting, views and opinions, while also enhancing students' critical literacy skills.

Further, Carreon (2018) investigated Facebook as an online teaching tool to supplement traditional classroom practices. The aim of the study was to examine how using Facebook as an online discussion forum affected learning outcomes amongst Year 7 students in the Philippines. A closed Facebook group was created to share and discuss a range of learning materials and subjects via multi-media and written posts, and audio-video presentations. The findings assert that students who engaged with the closed Facebook group improved significantly in learning performance compared to students who did not engage. The results concluded that Facebook augmented learning outcomes by allowing students to determine their own learning pace, and time and place, similar to learning management systems with built-in discussion forum capability. The study suggests that these practices enable learner autonomy, strengthen communication and collaboration, and fosters students' confidence and motivation during interactions (Carreon, 2018).

The research demonstrates that meaningful student engagement can be cultivated using interactive digital technologies. Digital communication and collaboration tools can create cross-curricular educational backdrops, which set the stage for academic learning in conjunction with improving digital literacy, 21st century skills and learning outcomes (Chang et al., 2018; Ciampa, 2017; Niemi et al., 2018; Oakley et al., 2018; Taylor et al., 2020). However, the direct application of such communication and collaboration tools into educational contexts needs to be carefully considered, particularly the use of Facebook, or similar externally managed discussion forums. Where available, learning management systems owned by educational institutions with embedded discussion forum capability should be used to ensure student privacy of data is maintained, and avoiding the necessity for students to use personal Facebook accounts for educational purposes.

3.2 Digital storytelling (DST)

While conventional bookmaking and storytelling have a rich tradition in schools, the use of technologies to support story planning, design and sharing enables students' oral and written communication skills to be built alongside digital literacy skills. Digital storytelling (DST) is a multimedia presentation of narratives, that combines a range of media such as text, images, video, audio, and interactive elements, to tell a story.

A study by Eubanks et al. (2018) investigated the effectiveness of integrating DST into writing workshops. The research observed Year 2 students, in a Chinese primary school language class, participating in daily writing lessons. The students' story writing process was scaffolded with customary materials such as, paper and crayons, by which they sketched story maps before digitally actioning their stories via various iPad apps. Digital capability included voice and video recording, inserting illustrations and images, handwritten or keyboard text, and the use of a specific Book Creator app to create and publish their stories. The object of this study was to determine if using DST influenced students' ability, and attitudes towards, writing stories. The findings showed a significant increase in students' Chinese writing ability, engagement, and motivation. Moreover, improvement in students' speaking, reading, and listening skills as language learners was also noted. The study deems that a digital hands-on approach to language learning is met with positive student attitudes, which contributes to favourable learning outcomes.

Further, a study on an Australia–China Council venture for middle school students in Australia and China (Oakley et al., 2018) examined how shared digital stories about their everyday lives, local cultures, and traditional tales impacted learning outcomes related to intercultural understanding. Using teachers' observations and perspectives, the research found that DST was a novel means to practice English and foreign language skills, and facilitate cross cultural understanding, 21st century skills and digital literacy. However, the teachers also identified various challenges, such as dealing with emergent cultural and pedagogical differences, incompatible technologies, and contrasting security restrictions impacting the ability to use shared platforms. To truly tap into the project's potential, the study asserts that online cultural exchanges need further exploration, as students will need linguistic, cultural and digital skills to effectively engage with our ever-growing globalised world.

The research highlights the potential and possibilities of DST to develop core language skills in tandem with digital literacy. Moreover, when DST is coupled with far-reaching digital communication and collaboration technologies, it can create an array of student learning opportunities and outcomes, and inspire innovative cross-cultural communication and learning (Oakley et al., 2018).

3.3 Language learning

Language learning relies on digital technologies and tools to facilitate vocabulary up-take, understanding and retention. However, a study by Vungthong et al. (2017) highlights the importance of integrating pedagogical guidance to help construct and convey meaning in language learning, rather than relying on technology alone. Vungthong et al. (2017) investigated how songs in apps aid English as a foreign language (EFL) learners. In particular,

the research explored how interactive audio-visual songs develop vocabulary awareness and understanding in primary school children, when delivered on computers and touch screen devices. The purpose of the study was to determine the relationship between images and language, and how video with songs on apps facilitated meaning–making. The research examined 23 videos with songs geared towards Grade 1 and 2 learners, focusing primarily on the images and lyrics of individual frames to explore visual-verbal relations. While songs are considered an enjoyable method to engage students and promote vocabulary, the findings show that images and lyrics cannot solely facilitate vocabulary uptake and understanding. Similarly, videos with songs or similar materials presented on apps cannot exclusively support students' understanding of abstract terms, or words with varied contextualised meanings, and need to be accompanied with pedagogical guidance.

The findings presented by Vungthong et al. (2017) are echoed in a systematic review by Eutsler et al. (2020), which explored the influence of touch screen apps on English language acquisition for early learners to Year 5 students. They found that studies reporting positive learning outcomes focused on singular literacy domains, such as phonics, vocabulary and comprehension. Thus, the review suggests that apps designed to target specific language components are of most educational value. Beyond targeting certain language skills, the studies could not determine if the apps have any effect on augmenting broader language and literacy development, as significant findings could not be established (Eutsler et al., 2020). Therefore, the role of English teachers cannot be 'outsourced' to digital language teaching materials alone, as teachers continue to play a critical role in supporting students to contextualise and develop comprehension of particular words (Vungthong et al., 2017).

A further study by Wilkes et al. (2020) points to the importance of technology and teachers working in unison to augment language learning outcomes. They examined the use of digital tools in a blended learning setting to augment reading proficiency. The purpose of the study was to determine if digital technologies and tools could better facilitate English language and literacy outcomes in early childhood education. The research revealed that a technology-based reading skills program was most effective only when coupled with reading guidance from teachers. These studies highlight that certain resources, delivered by digital technologies and tools, should be seen as supplemental materials as opposed to teacher substitutes (Wilkes et al., 2020).

3.4 Mathematics literacy

Interactive digital technology can provide dynamic maths instruction in everyday classroom practice by enhancing the learning process and making maths concepts more understandable.

A study by Niemi et al. (2018) investigated how maths literacy can be developed in fun and active learning environments combined with DST to help enhance maths literacy. The object of the study was to learn if DST could be applied to different educational contexts beyond language and literacy learning, and to observe its effectiveness as a mathematical teaching approach. Students aged 10 to 11 applied DTS to convey and discuss geometry concepts though illustrated narrations. The findings indicate that DST motivates learning and encourages students to explore, apply and communicate mathematics to each other using these novel methods.

Disney et al. (2019) examined play-based pedagogy, widely used in early childhood education, to study if play-based numeracy apps aided maths awareness and growth by building on previously acquired skills. Specifically, the aim of the research was to implement five play-based learning apps for three- to four-year-olds, and test for increased knowledge in 'numerical identification, counting, arithmetic problems, shape identification and patterns' (p. 171). The findings suggest that age specific numeracy apps can facilitate maths literacy, as overall increased performance was noted across the student cohort. However, the apps only serve as a practice platform to develop pre-taught maths concepts, rather than teach foundational maths skills. Thus, the research asserts that maths apps cannot replace initial numeracy instruction, as these digital tools extend rather than augment learning (Disney et al., 2019). The study demonstrated that digital play-based learning can facilitate maths literacy, as children learnt by engaging and exploring maths concepts to further establish knowledge by applying skills, strategies, concepts and rules in play-based maths apps.

3.5 Flipped learning

Flipped learning provides students with video lectures and other learner support materials designed to teach and guide students outside of the classroom. This allows valuable class time to be spent on more engaging and collaborative activities.

A study by Graziano and Hall (2017) looked into flipped learning for newly arrived English language learners in mainstream public high schools in the U.S. The aim of the study was to determine whether flipped algebra instruction impacted the students' maths learning outcomes. The results showed that there was no statistically significant difference in the academic performance of students enrolled in algebra with flipped instruction compared to students enrolled in the same course with no flipped instruction

In general, studies find that flipped learning has a positive effect on engagement, the ability to self-pace learning, and the provision of instant discussion and feedback during class time. However, it may not demonstrate additional learning gain when contrasted with traditional approaches. Regardless of student learning performance, the flipped learning students did find the videos and in-class activities to be helpful for improving their English speaking and literacy skills (Graziano & Hall, 2017). Current studies on flipped learning are limited, however, and there are no conclusive or generalisable findings that can be derived from the literature (Hung, 2015).

3.6 Gamification

Although educational games have been integrated into teaching practices for decades, digital games are now being recognised for their ability to improve student learning though increased cognitive activity, learning gain, and motivation (Domínguez et al., 2013; Hamari et al., 2014).

One study by Soboleva (2019) investigated the use of mobile game applications to support 'quests', whereby students used interactive mobile apps to find educational content on their own to solve problems. This vastly differs from traditional approaches to finding answers and completing tasks (Soboleva, 2019). Quests have a particular structure resembling that of a collaborative mystery-solving game and can be tailored for any age group, their needs and

interests. The purpose of the study was to test the effectiveness of using mobile game apps in the 'quest' game genre. In this study, Russian high school students completed a quest called 'Castle in the forest' where students open doors and solve problems that leads them out of the forest. The research revealed that students who participated in the quest improved their digital technology skills and their cognitive activity due to the interactivity and feedback received as they completed the tasks (Soboleva, 2019).

A similar study explored the use of interactive Physics eBooks (Hediansah & Surjono, 2019). Using an Android smart phone or tablet, junior high school students in Indonesia engaged with custom-built media-rich interactive games developed by their teachers using Adobe Animate to solve physics problems. The findings revealed that students who completed the Android-based physics games had a higher level of knowledge gain compared to those who learned the same concepts using traditional methods. These results illustrate the potential of gamification (Domínguez et al., 2013) with interactive media-rich play-based activities to increase student motivation and lead to improved student learning. Hediansah and Surjono (2019) concluded that digital games provide opportunity for interactive and independent learning leading to higher learning outcomes as well as highly enthusiastic students.

3.7 Augmented/Virtual reality (AR/VR)

Digital technologies using immersive simulations in Augmented or Virtual reality (AR/VR) can create a digital or completely virtual world for students. Various experiences can be computer-created to provide accessibility to different virtual scenarios in the classroom or to augment projections of different objects in a 2D or 3D space. As technology develops and the digital world looks more realistic, VR experiences have become even more immersive and the AR context content can be realistically projected and overlayed with the students' surroundings.

The use of virtual reality (VR) was studied by Fransson et al. (2020) with in order to inform organisational, contextual and practical challenges and opportunities in K-12 schools. A series of workshops were held to familiarise teachers with the technology and use of educational apps before being used in classrooms. However, it should be noted that the apps explored were not designed specifically for teaching purposes but had generic content. There are currently few educational AR/VR apps. Based on interviews with the teachers and on classroom observation, it was found that VR use is compelling, and the teachers see its potential for education, as it can add value in some pedagogical settings. At the same time, none of the teachers were 'over-enthusiastic' about VR as a revolution in education. They saw the benefits as adding value in making teaching and learning more interesting, affective, engaging, and fun, as it is varied, and experience based. VR also increased opportunities to visualise complex processes and bring status to instruction and teachers' work. It was found that VR/AR apps in K-12 schools may be used to promote learning but cognitive overload with certain apps can be a challenge.

Learning how to work and use VR in education will take some time (Fransson et al., 2020). In some cases, it was found that students' focus may be on experiencing VR rather than on the learning subject matter, but this challenge was also seen as a responsibility for the teacher in terms of developing the expertise to guide student learning. The impact of VR on classroom management and organisation was seen as a challenge by the teachers involved in this study,

and none of the teachers believed that VR could be used in whole-class sessions. Further, teachers preferred a well-integrated approach, where VR is a dedicated part of curriculum, course content and learning processes, by aligning the technology with content, aims and goals in an overall approach.

Further, Madanipour and Cohrssen (2020) conducted a review on the contribution of AR to teaching practice and learning outcomes in the pre-school years. They found eight articles that matched their search criteria and concluded that the use of AR can benefit child learning outcomes in the reported areas of drama, reading and alphabet learning, and art. AR was found to support child engagement, persistence, concentration and creativity. Moreover, they found that AR increases motivation, excitement and enjoyment, and social interaction and participation. The use of AR allowed children to explore objects from different perspectives supporting concept acquisition and development. However, they also concluded that none of the studies provided suggestions about how AR technology could be incorporated in informal play-based early childhood curricula, revealing a gap in the literature that still needs to be addressed.

3.8 Modelling software

Kotsari and Smyrnaiou (2017) explored how modelling software and digital tools can enhance inquiry-based science learning. In particular, the purpose of this study was to determine how modelling software and digital tools, such as science databases, multimedia, and online collaboration sites, can help students generate scientific meanings on geometrical optics. In this study, students were drawn into virtual learning settings and online communication spaces in which scientific meaning-making can be established via simulated interactions with various geometric models and representations. Aligning with inquiry-based learning pedagogy, the students used modelling software and digital tools to pose questions, investigate, build new understandings and knowledge, collaborate with peers, and find answers.

The results suggest that modelling software and digital tools increase engagement and facilitate positive learning outcomes (Kotsari & Smyrnaiou, 2017). Students can enhance their communications with visual simulations during peer discussions and debates to further their understanding.

While the potential to generalise from this study is limited due to the small sample size (Kotsari & Smyrnaiou, 2017), the research highlights some potential teaching and learning benefits of modelling software. From participating in novel digital environments, teachers can present materials in innovative ways, which creates opportunities for students to digitally explore the world from different perspectives.

3.9 Spherical videos

Fokides and Kefallinou (2020) explored how spherical videos (SVs) can be used as effective mediums to impart knowledge about environmental issues in primary school settings. SVs are filmed by cameras, which capture images covering a 3D sphere instead of capturing images from restricted angles. The SVs can be played on computers, smartphones, and headsets

(Siegle, 2019). The aim of the research was to establish whether SVs, embedded into interactive apps, are useful teaching tools in comparison to printed material and web pages. The study also examined students' attitudes towards SVs. The findings assert that SVs improve students' knowledge uptake and retention compared to other teaching tools. Additionally, students showed favourable attitudes towards learning with SVs. Fokides and Kefallinou (2020) suggest that an increased feeling of presence in SVs contributes to learning, as users are exposed to virtual realities and experiences, which enables understandings of concepts, processes and problems. Moreover, the study asserts that the fun nature of the experience, and the feeling of immersion within SVs, enhances learning outcomes, by facilitating enjoyment and thus increasing engagement and motivation to learn (Fokides & Kefallinou, 2020). SV concepts and factors of attraction warrant consideration for educators wanting to employ novel digital tools and technologies into everyday classroom practice.

3.10 3D Printing

Chien (2017) conducted a teaching experiment using design software and 3D printing technology to design race cars. The aim of the study was to compare student performance during the creation process of both 3D-printed and manually constructed cars. The experiment evaluated students' differences in creativity, race forecast accuracy, and learning performance (Chien, 2017). The results showed that students who used design software and 3D printers significantly outperformed students who made their cars by hand with respect to creativity (novelty, sophistication and functionality) and their ability to predict racing outcomes. However there was no sigificant difference in learning performance between the two groups. An overall evaluation of learning performance was carried out by three in-service technology teachers by giving each student a score from 0 to 100. While learning performance was similar for all students in this experiment, this research shows that utilising technology can foster a visual depth of understanding, and add richness to learning by allowing students to conceptualise, design and create with a dynamic digital perspective.

Chien's (2017) research suggests that design software and 3D printers enable students to flexibly employ STEM knowledge, capitalise on creativity, create novel sophisticated cars that meet basic engineering standards, and calculate race outcomes. Lipson and Kurman's (2013) study supports these findings. They assert that design software and 3D printing better able students to understand abstract concepts, visualise virtual objects, and produce tangible models.

3.11 Developmental and visual disabilities

Some studies suggest that the ease and accessibility of digital technologies, such as tablets with touch screen interfaces, can accommodate many students with developmental and/or visual disabilities, while digital or ePortfolios provide opportunity for holistic assessment.

Rivera et al. (2017) explored how primary school students with developmental disabilities can acquire science vocabulary and digital literacy skills via touch screen devices. The purpose of the study was to observe how digital tools, such as multimedia shared stories including video and written texts, can be used to mediate knowledge building and model touch screen skills. The study found that these tools facilitate academic and functional learning and, when used in

conjunction with multimedia theory principles, are integral for special education (Rivera et al., 2017). Moreover, research on middle school and high school students using touch screen devices has shown favourable outcomes in special education. For example, one study reported that using iPads empowered students to be 'experts' while concurrently improving their digital skills, and helped bridge differential access to technology (Ciampa, 2017). Similarly, *Reading Adventure Time!*, a mobile app for teaching reading to children with visual disabilities, was shown to motivate students and improve their literacy and digital technology skills. This indicates that the app could be a valuable supplement to classroom instruction (Kamei-Hannan et al., 2020).

Further, Clancy and Gardner (2017) report a case study where ePortfolios were introduced to help assess high school students with severe disabilities.[1] Effective assessment in special education is a much-debated issue. Assessment needs to be valid, reliable and usable to be effective, but questions are raised about effective instruments of assessment in special education. Digital technologies provide additional means to capture student learning and progress in ways that standardised assessment cannot fully provide. The use of ePortfolios has begun to enter assessment practice for students with special needs. They can help teach self-advocacy skills by providing opportunities for students with disabilities to engage meaningfully with their own work, as well as self-reflect and assess. ePortfolios have been shown to support a transition from assessing student outcomes to demonstrating student capability and interest. ePortfolios can facilitate the articulation of students' progress towards vocational and employment goals. The outcome of this case study points to the usefulness of digital portfolios for the capture of students' skills and progress to be used for assessment, especially in non-academic domains, such as life skills.

These studies indicate that digital technologies can be largely beneficial for students with disabilities, as they can supplement teaching and learning pedagogies, aid in tracking progression and assessment, and cater for individual needs.

4. School system operations and teacher support

Workplaces are evolving into open, transparent, flexible spaces designed to support collaboration, knowledge sharing, creativity, engagement and collaborative decision making. These features have entered our schools as well, which is evidenced by offering flexible spaces and furniture to facilitate group work, an increasing the number of outlets for using digital devices, introducing broadband, etc. These new ways of working and learning are informed by a modern vision of how teaching and learning in the 21st century impacts how we design and assess learning, and the way we think about digital technology in our classrooms.

Another aspect of the modern workplace is the deep integration of systems and platforms that enable schools to interact and respond to data about learners, collaborate internally and externally, and communicate with parents and stakeholders to develop community engagement. School leadership will be critical to lead the professional development needs of

[1] See section 4.1 for discussion of ePortfolios in mainstream schooling

teachers as well as to support each other in the development of the required digital skills and competencies. Literature reviewed in this report indicates that various technologies are being employed, but large-scale systemic change will need sufficient investment in teacher training and support. This section shows that support can be effective if stakeholder engagement utilises teachers in a key role for developing resources together to collectively support the teaching community's needs. This section also presents a key digital learning initiative, based on bringing your own device (BYOD), by discussing the results of a recent study in New Zealand.

4.1 ePortfolios

A modern school workplace should provide teachers and administrators with technologies or systems to help inform student progress and optimise work processes. It is essential that several systems are connected and provide information to support the workflow. The integration of digital portfolios (also known as 'ePortfolios') into schools and teaching practices can be seen as an example of improving the educational workplace. ePortfolios are defined as a digitised collection of artifacts reflecting student achievement to document the process of student learning as well as its outcomes. ePortfolios have been most successful in terms of creating opportunities for project-based learning, increasing student reflection, as well as increasing communication between staff and parents. Further, the use of the digital ePortfolios increases the opportunity for related service professionals to assess student development in particular domains.

A case study by Clancy and Gardner (2017), which aimed at exploring ePortfolios in action, demonstrates the capability of digital technology to optimise the educational workplace. By aligning systems to inform learning progression and improve communication and engagement of different stakeholders (e.g. domain experts, special needs educators and parents), ePortfolios support the provision of teaching and learning. ePortfolios 'have been able to assess student development more fully and accurately in content areas both in the classroom and in the community, provide students with increased opportunities to engage in the learning process, provide parents and organisations with a lens into a students' current functioning levels and provide an effective structure for incorporating multimedia work into student work portfolios' (Clancy & Gardner, 2017, p. 99).

4.2 Data-driven decision making

Trends and developments in the domain of data-driven decision making are mostly driven by advancing the use of digital data to make informed decisions about teaching and learning. Learning analytics, for example, uses data associated with a learner's interactions with content, other learners, and the educational institution to inform decisions and evaluations about teaching practices, personalised content, and interventions needed for learner success (Dawson & Siemens, 2014). At a systems level, researchers have recently argued for the development of data lakes and data integration to perform learning analytics at scale and support the uptake of artificial intelligence to enable real-time feedback (De Laat et al., 2020). The aim of this work is, for example, to improve the student learning experience and well-being to support growth. Traditional approaches to assessing learning and tracking progress for all learners, especially Indigenous and underserved populations, in acquiring needed skills and mindsets

are inadequate to meet this challenge. Digital data enables the development of learner profiles (Kovanović, 2020) to measure and shape student learning gains and provide adaptive and personalised guidance and feedback.

While learning analytics, artificial intelligence, and the development of learner profiles are in their infancy in early years, primary, and high school education, there have been advances in data-driven decision making in recent years. Even though data-driven decision making (DDDM) in schools strongly relies on data from standardised surveys and classroom observation (Dudek et al., 2019; Fallon et al., 2019; Singh, 2018), the use of integrated digital platforms and systems to provide a steady data stream is on the rise. With such systems in place, DDDM can be utilised more effectively to detect learner differences, address personalised learning, and augment students' learning achievements. DDDM appears conducive to making informed decisions concerning student capabilities.

For example, a study by Bradbury (2019) examined the process of datafication in early childhood education. Fundamentally, this process situates data as an inherent component of the educational environment, embedded in the teaching and learning cycle, and which informs and guides instruction to make iterative changes to facilitate optimal learning outcomes. Bradbury's study aimed to investigate how ongoing data collection on phonics assessments facilitates accurate student grouping according to ability levels. The findings suggest that the combination of data analysis and teachers' observations assists informed decision making and systematic organisation, enabling instructors to meet learner differences, and therefore, improve students' learning outcomes (Bradbury, 2019).

Another paper (Buzhardt et al., 2020) explored how DDDM can assist educators to identify and provide personalised guidance to early learners who require extra literacy and language support. The results showed that progress monitoring data systems enable early detection of underperforming children, and thus assist teachers and parents to respond accordingly by implementing individualised strategies to facilitate language development (Buzhardt et al., 2020).

Recent technological advances have led to novel wear-able real-time analytics tools that support teachers' data-driven decision making (De Laat et al., 2020). One such tool, Lumilo, is designed for teachers to receive real-time information about how students are faring while they complete software-based mathematical activities on the computer in class (Holstein et al., 2019). The teachers wear Lumilo, a form of smart glasses, which gives them information on when students are struggling with their learning tasks. The use of Lumilo had a mediating effect and narrowed the gap in learning outcomes across students with different prior knowledge (Holstein et al., 2019) by providing teachers with information that they otherwise would not have had access to, helping them identify students who require additional assistance.

Further, the design and use of data-driven systems, such as learning analytics tools in K-12 classrooms, suggests that it is important to engage teachers (or non-technical stakeholders) throughout the entire design process (Holstein et al., 2019). The advantage is that co-design processes help to centre discussions on needs and possible teacher interventions, rather than on the specific type of analytics and technical considerations. It also helps to ensure usefulness and ideas on how to inform instructional decision making and actioning in the context of

specific tasks and scenarios. However, while some research on learning analytics has been explored in schools, it has largely been investigated within higher education; therefore, there is limited knowledge of the specific challenges for schools in the K-12 space (OECD, 2021).

4.3 Professional development

As the previous sections have demonstrated, teaching and learning in education can be supported through effective digital strategies. Both teachers and students across all education levels require different considerations to ensure support for learning, however upskilling in overall digital literacies is required for all. This section addresses teachers' readiness and competencies regarding the uptake of digital technology in their practices. The strategies of other Australian states (e.g. NSW Department of Education, 2019) reinforce the need to support teachers with the development of digital skills and literacy for themselves and their students; a similar conclusion was presented in a review of digital education practices across a range of countries (Marrone et al., 2021).

Overall, the focus on teacher needs is explored through the provision of professional development along with the provision of new technologies in schools. High quality support and professional development is critical for all teachers, not only those who may be enthusiastic or early to trial different technologies. However, research is still needed to unpack broader requirements and impact at the system level scale.

Studies included in this review suggest that teachers agree that there are benefits for using digital technology in teaching and learning (Al-Hezam, 2017; Fokides & Kefallinou, 2020; Fransson et al., 2020). Al-Hezam (2017) reported that teachers identified benefits of digital technology as including ease of information delivery and attractiveness of the tools to students (p. 51). Success in integrating and using digital technologies in education is, however, driven by well-informed teachers and quality leadership. Well-informed and high-quality teachers drive quality education (Hopkins & Stern, 1996). Thus, teachers should be consulted and involved throughout the digital strategising process. To build and impart digital knowledge, teachers can contribute through collaborative involvement in developing digital strategies and resources. Being part of this processes enables teachers to become well equipped, have ownership, and maintain teacher agency (Clancy & Gardner, 2017; Misfeldt & Zacho, 2016). Murray et al. (2019) assert the need for 'establishing a shared vision and technology integration plan, [as well as] shifting attitudes and beliefs, efforts to improve professional development, and reconsidering assessments' (p. 58). Many of the articles included in this literature review strongly point to these aspects, and forefront the need for professional development to support the use of digital technologies in teaching and learning (Callaghan et al., 2018; Ciampa, 2017; Clancy & Gardner, 2017; Dirckinck-Holmfeld et al., 2019; Engeness, 2020; Fokides & Kefallinou, 2020; Fransson et al., 2020; Kilbane & Milman, 2017; Marsh et al., 2016; Misfeldt & Zacho, 2016; Moyer et al., 2018; Murray et al., 2019; Nguyen et al., 2018; Niemi et al., 2018).

Teachers need to be ready, and the success of the use of digital technology cannot rely on the enthusiasm of early adopters and their capability to provide collegial support. It was found that teachers' experience with technology, and how to deal with the functionality of technology or

devices in classrooms, can be seen as a challenge (Al-Awidi & Aldhafeeri, 2017; Fransson et al., 2020; Hill & Valdez-Garcia, 2020), impacting their confidence in the uptake of technologies (Nicholas & Fletcher, 2017). This challenge may further impact the initial appreciation, or the value that digital technology may offer in terms of pedagogical benefits (Fransson et al., 2020; Hill & Valdez-Garcia, 2020; Misfeldt & Zacho, 2016; Nguyen et al., 2018; Nicholas & Fletcher, 2017).

Fransson et al. (2020) summarise that the main challenges are related to economic or financial resources, overcoming initial learning barriers, changing classroom organisation and management of teaching and learning, teacher competencies, trust in own skills and impact on learning content and outcomes. Like Fransson et al. (2020), Hill and Valdez-Garcia (2020) conclude that lack of time, incentives, and technology support, understanding how to integrate technology in pedagogical practices, and access (availability and classroom management) were found to be the primary obstacles to utilising technology in the classroom successfully. For digital technologies to be effective, it is evident that teacher support and professional development requires on going investment and attention.

Globally, teachers are moderately ready for the implementation of a digital curriculum. This is primarily due to two main findings, the first being technical readiness and the second being pedagogical readiness. Both of these factors are influenced by time constraints, lack of knowledge and skills, and infrastructure and technical support (Al-Awidi & Aldhafeeri, 2017). Callaghan et al. (2018) concluded further that identifying resources that teachers find both easy to use and relevant to their teaching may be the key to technology integration and, ultimately, increase student learning (Callaghan et al., 2018, p. 18).

4.4 Teacher engagement and ownership

Digitalisation of teacher workplaces and leadership can facilitate teacher engagement and involvement in educational transformation. Some studies explicitly pointed to the added value of engaging teachers in the design and implementation of digital technologies in schools. Clancy and Gardner (2017) recommend teacher engagement in communities of practice and using participatory design (Holstein et al., 2019), future workshop, or scenario design (Misfeldt & Zacho, 2016) approaches to actively involve teachers in discussions and decisions around the use of digital technologies. This is especially important as being involved in decision-making processes around the adoption of digital technologies approaches affords the teachers a sense of ownership (Clancy & Gardner, 2017).

Sun and Gao (2019) explored the role of school leaders and teachers during a school-wide reform project aimed at using digital technologies to adopt a flipped learning model. Key results highlighted the need for appropriate school leadership that is distributed across the school, including the principal, administrators and teachers. To enact this leadership, the school developed pedagogical and organisational systems that support collaboration and shared learning experiences. This helped teachers develop four new roles as learners, researchers, collaborators and facilitators of student-centred learning. The school was able to successfully implement this new teaching model incrementally over time. New policies and curriculum were developed which reinforced notions of a supportive teaching environment and provision of professional development. In stages, the model was adopted by teachers conducting research,

and additional training was offered. A technology coordinator assisted with effective implementation: 'The changing teacher role from the authority to facilitator of students-centred learning resulted from both the learning and the teaching practice supported by ICT. The use of online instructional videos in the flipped learning model freed teachers from lectures and enabled them to work with individual students in collaborative activities rather than the whole class' (Sun & Gao, 2019, p. 1124). During this change some teachers also began researching their practices to support better pedagogy and to improve their teaching and learning.

4.5 Bring your own device

The Bring Your Own Device (BYOD) policy has been largely adopted across a range of school systems and countries. While they all may have a different flavour, the policies have some similarities. One case study conducted by Adhikari et al. (2017) reports on a five-year longitudinal study of BYOD policy in a secondary school in New Zealand. Their study focused on understanding personal, behavioural and environmental factors that influence digital capability and learning outcomes, and which are known to result in a digital outcomes divide.

According to Wei et al. (2011), the advancement of digital technology adoption influences a new digital divide with equity of information literacy, and differences in learning outcomes could occur. More recently, the digital outcome divide is considered to be the third level of divide, with the first digital divide being access, and the second being digital capability.

A case study by Adhikari et al. (2017) investigated how the BYOD policy contributed towards transformation of digital skills and literacy, and the organisational challenges encountered along the way. The BYOD policy brought changes to computer self-efficacy among learners, as well as changes in attitudes towards student learning. Based on interviews with teachers involved, they found a gradual disappearance of the boundaries between formal and informal learning spaces to allow for participation in learning activities and collaboration. It was found that learning activities that started in the classroom could be worked on collaboratively and completed from anywhere (for example, from home). It was also found that different modes of collaborative activities resulted in improved student motivation. This in turn helped teachers to change their whole curricular strategy to maximise the potential benefit of BYOD policy. The teachers also concluded that the BYOD policy strongly contributed to improving learning outcomes. Some of the concerns that were raised during the study relate, for example, to the technological infrastructure. A unified approach around the learning management systems and other tools to support overall learning activities was lacking. There was an absence of a common workflow model that supported or articulated processes and procedures at an organisational level.

Overall, the findings point to positive improvements in school and classroom curricular practices in a bid to achieve success of the BYOD policy. This success has been a combined effort of school management, teachers and support from stakeholders, such as parents.

Another area of good progress within the BYOD policy is that the teaching and learning practices/methods have been designed in such a way that the learner gains greater freedom and flexibility in participating in learning activities. This has contributed to learners being more independent and taking greater responsibility for their learning.

5. Conclusion

The complex educational ecosystem involving students, parents, teachers, and school systems is highly interconnected. Digital technology provides positive learning outcomes, inspiring and motivating to students as learners in a digital world beyond the constraints of the classroom. To learn, collaborate and connect in a digital world, students need to develop 21st century skills in unison with using digital technologies. Creating connected and communicative online and face-to-face learning spaces, assisted by digital technologies and tools, could support learning innovation, engage and motivate students, and enable students to develop vital skillsets to become job-ready in the future, particularly if equitable access to digital technology is enabled.

Teachers play an important role in this ecosystem. They provide a voice to how those systems can be developed to support the educational outcomes for students. To best support student learning it is highlighted that teachers need professional development and agency in their teaching and learning practices. Other digital strategies explored across OECD countries, as published in a recent working paper (OECD, 2021), highlight the importance of government policy and the development of specific digital strategies to improve teaching and learning and build proficiency in the educational workforce. This literature review identified that teacher competency and overall digital literacy skills can be developed with appropriate teacher-focussed training. Teacher engagement, support and professional development are crucial factors for the successful integration of digital technologies in education. Innovative professional development, which caters to collective and individual teachers' technological needs, may need to be implemented.

There is also acknowledgement around student data and how this can be used to inform more system-wide decision making. However, this decision making needs to be completed collaboratively and in context. Results from the research highlighted the need for distributed school leadership that was spread across the school and across various roles? including the principal, to administrators and teachers. Any systems implemented should foster collaboration and maintain learning communities amongst stakeholders to create a collective school culture; for example principals and teachers, administrators and teachers, teachers and teachers, and teachers and parents, and students.

In addition, principals and teachers may need to upskill in data analysis to assist them in formulating approaches and strategies (with other stakeholders) in response to emergent student needs (or make predictions of future student needs) from information generated from educational data more broadly. Currently, data-driven decision making in schools strongly relies on data from standardised surveys and classroom observation, however the use of integrated digital platforms and systems to provide a steady data stream is on the rise.

Many studies explored in this review focussed on single-use technologies in single classrooms (i.e. case studies) rather than across a whole school or school district/area context.

Overall, further studies are needed to explore digital technologies across multiple contexts within a student's school week, year or between years across specialist curriculum content rather than individualised studies that do not interconnect across a student's whole learning

journey. However, the findings gleaned from the studies provide suggestions for the ways that digital technology could enhance learning outcomes and be integrated into school systems.

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