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Pedagogical Strategies, Approaches and Methodologies to Support Digital Literacy

A Review of the Literature

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Recommendations

1. Digital literacy is defined as:

a complex orchestration of a range of skills, strategies, dispositions and social practices to leverage technology to access, acquire, comprehend, analyse, evaluate, create and communicate knowledge in multiple modes and through multiple representations to and with a variety of audiences and in a variety of contexts for a range of purposes (Dwyer, 2020 drawing on NCCA, 2019).

2. Teachers need to create collaborative, authentic, learning environments, and engage and scaffold students through explicit strategy instruction and modelling, so that students develop the skills, strategies, social practices, and dispositions they require to learn in digital environments. Digital literacy should begin in Early Childhood Care and Education and continue into primary and post–primary settings (Dwyer, 2013; 2020; Leu et al., 2018; Tamborg et al., 2018). (Curriculum and the learning experience)
3. Teachers must consider curriculum goals and learning outcomes for students before considering the meaningful use of technology to enhance literacy and learning in the classroom (Martínez-Bravo et al., 2020; Mishra & Koehler, 2006. Røkenes & Krumsvik, 2014; Rybakova et al., 2019). (Curriculum and the learning experience)
4. Practice should be underpinned and grounded in research. A robust research-to-practice focus should be firmly grounded in classrooms and other learning spaces. (Bradley & Reinking, 2011; Yang et al., 2018). (Curriculum and the learning experience)
5. Issues of equality of opportunity, excellence in instruction, social inclusion, and social justice should underpin all that we do to ensure that all students, regardless of ethnicity, age, geographical location, class, gender or socio-economic status (SES), have equitable and quality access to digital technologies for literacy and learning in classrooms, homes, and communities (Martínez-Bravo et al., 2020; Rybakova et al., 2019; Scheerder et al., 2017) (Curriculum and the learning experience)

6. Teachers need to consider their role in advocating for the appropriate use of technology with young children, and the optimal use of digital technology in classroom and ECEC settings (Joint Research Centre (European Commission) et al., 2018; Mantilla & Edwards, 2019; Marsh, 2019; Marsh et al., 2016) (Teachers and ECEC CPD)
7. Incorporating digital literacies, multiliteracies and multimodalities into the classroom and ECEC setting is complex work. Teachers need professional development and professional learning opportunities in order to engage their students in meaningful literacy practices, incorporate effective pedagogies and design and create authentic collaborative learning spaces (Colwell & Hutchinson, 2015; Williams & Beam, 2019). (Teachers and ECEC CPD)

Summary

1. Digital literacy is defined as:

a complex orchestration of a range of skills, strategies, dispositions and social practices to leverage technology to access, acquire, comprehend, analyse, evaluate, create and communicate knowledge in multiple modes and through multiple representations to and with a variety of audiences and in a variety of contexts for a range of purposes (Dwyer, 2020 drawing on NCCA, 2019).

- Digital literacy is a deictic rather than a static construct that is constantly evolving. Being digitally literate involves our students in socially situated practices supported by skills, strategies, stances, social practices, and dispositions that enable knowledge development and learning, and the generation, representation and understanding of ideas using digital tools (Dwyer, 2013 ; Leu et al.,2018).
- Digital literacy is underpinned by a range of theoretical perspectives (Cope & Kalantzis, 2000; Kress, 2003; 2010; Lankshear & Knobel, 2003; Leu et al.,2004; Pahl & Rowsell, 2005;The New London Group, 2000).
- In classrooms, practice should be underpinned and grounded in research. Research should move beyond the novelty of technology use in classrooms, to consider the social context along with the *why* and *when* of how technology could be used to support literacy and learning. Teachers must consider curriculum goals and learning outcomes for students before considering the meaningful use of technology to enhance literacy and learning in the classroom (Mishra & Koehler, 2006; OECD, 2017).
- Issues of equality of opportunity, excellence in instruction, social inclusion, and social justice should underpin all that we do to ensure that all students, regardless of ethnicity, age, geographical location, class, gender or socio-economic status (SES), have equitable and quality access to digital technologies for literacy and learning in classrooms, homes and communities (Martínez-Bravo et al., 2020; Rybakova et al., 2019; Scheerder et al., 2017).
- Online reading skills are built on foundational print-based skills but reading is more complex in an online environment (Dwyer, 2020). The way in which everyday literacy practices and communication have been transformed by technology require teachers to consider their role in advocating for the appropriate use of technology with young children, pupils and adolescents, and the optimal use of digital technology in

classroom and ECEC settings (Herodotou, 2018 ; Hsin et al., 2014; Zheng et al., 2016).

- Critical evaluation of information in an online environment introduces new complexities for the reader as the Internet is an un-vetted open network where anyone can publish any information. Evaluation of online information includes critical evaluation skills, critical thinking skills, critical literacy skills, and media-savviness and information literacy skills (Dwyer, 2022). These skills are required to evaluate, corroborate, and interrogate the accuracy, reliability, objectivity, credibility, and veracity of information presented online (Leu et al., 2007). Therefore, it is important to help our students to develop the high level skills needed to develop a healthy skepticism about what they read online (EC, 2018; EC, 2022).
- Screens cannot replace interactions with an adult when reading, but multimedia books have a positive impact on children's learning when compared to children reading alone (Takacs et al., 2014; 2015). Features of multimedia stories can have positive or negative effects and digital enhancements must be related to the story and relate to children's interests (Takacs, Swart, & Bus, 2015).
- Students' attitudes towards technology usage is identified as a key element of increasing digital literacy (Tamborg et al., 2018; Yang et al., 2018). Digital technologies are effective in motivating and engaging students (Chen & Macleod, 2021).
- Students leverage technology for reading, writing, and communicating as they access, acquire, comprehend, analyse, evaluate, create and communicate knowledge in multiple modes and through multiple representations (Barrot, 2021; Chen & Macleod 2021; Colwell & Hutchison , 2015; Dwyer & Larson, 2014; Williams & Beam, 2019).

Digital Literacy

The Internet, digital technologies, and digital media are powerful tools for literacy, for learning, and for communication in contemporary societies. As we navigate the Internet, use digital tools, and connect with digital media as part of our various social, cultural, educational, political, and economic activities we interact with a myriad of multimodal texts and digital technologies. As a result of these interactions how we define literacy and indeed what constitutes ‘being literate’ is evolving. Print based literacy remains as important as ever. Moreover, digital literacy skills are built on foundational print based skills. However, reading is more complex in online and digital environments. As students leverage technology for literacy and learning they access, acquire, comprehend, analyse, evaluate, create and communicate knowledge in multiple modes and through multiple representations. Therefore, print based literacy and digital literacy are not isomorphic. Digital literacy is more complex. Therefore, in schools and communities, as our students interact with digital technologies and multimodalities to engage with and create new and more complex texts, additional skills, strategies, dispositions and social practices are required to successfully use the Internet and other technologies to deepen and enhance literacy and learning in the classroom (Dwyer, 2013).

This paper presents a review of systematic reviews and meta-analyses carried out since 2011. Where appropriate, the review is supported with references to international reports and other seminal articles. Many of the reviews identified for inclusion in this report focus across the spectrum of Early Childhood Education and Care (ECEC), primary and post-primary settings. Where appropriate we identify specific age ranges.

Defining Digital Literacy

The adoption of a definition of digital literacy across new national literacy, digital literacy, and numeracy strategy (NLDLNS) and other curriculum documents is critical if we are to ensure consistency across the system. This need is stressed in the Digital Strategy for Schools to 2027 (DE, 2022); however, defining digital literacy is not an easy task. Across the systematic reviews and meta-analyses reviewed, there is no one clear or accepted definition of digital literacy. In their review of 55 articles Tamborg et al. (2018) revealed that digital

literacy is often not defined or is substituted with another similar term, and that established definitions of digital literacy are combined with theories from other fields.

Terms such as 21st century skills, digital competences, digital skills, and digital literacy are often used interchangeably with many scholars seeking to distinguish between them. It is our belief that the commonalities and the distinctions between these terms are important to consider as we move towards understanding digital literacy in the context of the new national literacy, digital literacy, and numeracy strategy (NLDLNS).

A systematic review of 75 articles van Laar et al. (2017) noted that 21st century skills are not necessarily underpinned by digital technologies. This review identified seven core skills as technical information management, communication, collaboration, creativity, critical thinking and problem solving. In addition, five contextual skills were pinpointed as ethical awareness, cultural awareness, flexibility, self-direction, and lifelong learning.

There has been increasing interest in outlining and detailing the specific knowledge, competences, attitudes and skills that young people need to become sufficiently digitally competent (Butler & Leahy, 2022). Recent emphases favour broader competency models that encompass the diverse knowledge, capabilities, dispositions and values needed by individuals to learn, work and participate in society. Digital literacy or meaning making in online, multimedia environments is often presented as embedded in or as a subset of these models. For example, information and data literacy is included as one of five key competences included in DigComp 2.1 (Carratero, 2017).

Three of the systematic reviews explored as part of this literature review distinguish between digital literacy and digital competency. Digital competence is central to the review conducted by Røkenes and Krumsvik (2014). Drawing on Erstad, Kløvstad, Kristiansen, and Sjøby (2005, p. 8), they define digital competence as the “skills, knowledge, creativity, and attitudes that everybody needs in order to use digital media for learning and functioning in the knowledge society” (cited in Røkenes & Krumsvik, 2014).

Focusing on digital literacy, the systematic review conducted by Martínez-Bravo et al. (2020) sought to identify the conceptual contributions of each of a range of 11 key terms (e.g. Information Literacy, New Literacies, Technological Literacy, Digital Competence, ICT skills, ICT competencies, ICT Literacy) to develop an integrated framework of digital

literacy. Following this analysis, the authors propose a definition of digital literacy which encompasses two perspectives. First, focusing on skills-competencies for the use of technology at the personal, professional and citizen level. Second, on teaching-learning and its strategies for digital literacy both in the context of life-long learning and 21st century competencies.

In their comparative review, Pangrazio et al. (2020) analysed how the term digital literacy has been conceptualised and applied by scholars in Australia, Sweden and Argentina. Across all three contexts, they found that digital literacy refers to something broader than digital competence, digital skills or digital proficiency. Digital competence, for example, refers to the specific set of skills required to be digitally literate, whereas digital literacy refers to skills as well as dispositions, including the tacit and social practices associated with digital media use. The authors conclude that digital literacy involves more than the functional use of digital devices and is the “ability to creatively engage in particular *social practices* to assume appropriate *social identities* and to form and maintain *social relationships*” (italics in original) (Jones & Hafner, 2012, p.12 cited in Pangrazio et al., 2020). This view is echoed by Shin & Seger 2016 (cited in Tamborg et al., 2018) who suggest that digital literacy should be considered as a product of the cultural, social, political and material capital of students and their parents.

The importance of reflecting digital literacy as a product of the cultural, social, political and material capital is already a belief somewhat reflected in the Irish context. The Department of Education and Skills (DES) (2011, p.8) views literacy as “the capacity to read, understand and critically appreciate various forms of communication including spoken language, printed text, broadcast media, and digital media.” At primary level, the National Council for Curriculum and Assessment (NCCA) sets a vision for children as communicators, readers, writers and thinkers within the Primary Language Curriculum (PLC) (NCCA, 2019). Building on this, the PLC further notes the importance of digital literacy as an important aspect of children’s learning in school. The PLC supports children’s abilities to engage with technology in meaningful ways for literacy development and learning. Drawing on the conceptualisation of digital literacy in the PLC, the NCCA support materials for developing *Internet Research and Inquiry Cycle* skills Dwyer (2020) proposed a definition of digital literacy as

a complex orchestration of a range of skills, strategies, dispositions and social practices to leverage technology to access, acquire, comprehend, analyse, evaluate, create and communicate knowledge in multiple modes and through multiple representations to and with a variety of audiences and in a variety of contexts for a range of purposes (Dwyer, 2020 drawing on NCCA, 2019).

This definition can be considered to embrace not only primary and post primary but can also be extended to the ECEC settings where Marsh (2019) defines digital literacy as including the acquisition of traditional skills related to print, but also skills related to accessing and using digital technology and to the “processes involved in accessing, using and creating knowledge” (p.21). This should include enabling children to explore digital tools by interacting with them not just as consumers, but as creators and producers.

Digital Literacy and Underpinning Theoretical Perspectives

Given that what constitutes digital literacy is evolving and given the lack of an accepted definition of digital literacy, it is not surprising that there is no one single, unifying, defining theory underpinning digital literacy (Leu et al., 2018). Rather, understandings and approaches to digital literacies reflect multiple theoretical perspectives. For example, Multiliteracies (Cope & Kalantzis, 2000; The New London Group, 2000) and Multimodality (Kress, 2003; 2010) explore the multimodal nature of digital literacies as embedded in semiotic systems, and evolving from the social practices of a culture within a globalised communication network. New Literacies Studies (Lankshear & Knobel, 2003; Pahl & Rowsell, 2005) situate digital literacies within sociocultural perspectives. New Literacies (Leu et al., 2004; Leu et al., 2018) perspectives are rooted in socio-constructivist and cognitive theories.

The range of theoretical perspectives challenge educators to transform reading and writing instruction in response to emerging technologies and new forms of communication and collaboration. In a systematic review examining the relationship between research, theory, and practice, between 2004 and 2015, in two prominent practitioner journals of the International Literacy Association (ILA) (*The Reading Teacher* and the *Journal of Adolescent and Adult Literacy*), Yang et al. (2018) explored the theories guiding the use of technology for reading instruction. Their findings revealed that the articles tended to focus more on what types of technology have been used, how they have been implemented, with

much less attention paid to why such technologies have been effective or ineffective. The authors also found that while theories such as, sociocultural perspectives (33%), reading motivation theory (30%), social constructionism (27%), and dual coding (25%) were drawn upon, these theories were implicitly rather than explicitly stated in the articles, suggesting a disconnect between theory and practice. The disconnect between theory and practice suggests the need for a robust research-to-practice focus that is firmly grounded in classrooms and other learning spaces to see what works and in what circumstances (Bradley & Reinking, 2011).

In sum, digital literacy is a deictic rather than a static construct that is constantly evolving. Digital literacy is underpinned by a range of theoretical perspectives. In classrooms, practice should be underpinned and grounded in research. Being digitally literate involves our students in socially situated practices supported by skills, strategies, stances, and dispositions that enable knowledge development and learning, and the generation, representation and understanding of ideas using digital tools. The systematic reviews explored urge that research move beyond the novelty of technology use in classrooms, to consider the social context along with the *why* and *when* of technology use to support literacy and learning.

Including all Learners: Embedding Digital Literacy in Classroom and Early Childhood Settings

In Ireland, the Digital Strategy for Schools to 2027 (DE, 2022) advocates the adoption of digital technologies in all teaching, learning and assessment activities as a “key enabler to facilitate equity of opportunity in education and to ensure that all students are supported to fulfil their potential and throughout their schooling, develop the skills and understanding necessary to navigate safely and productively in a digital world” (p.12). Issues relating to access, equity, inclusion, and social justice must be considered and underpin all that we do as we embed digital literacies into classroom practice. Equally, the role of digital technologies in the lives of young children and the importance of equipping them with the skills they need in a technological age has received increasing attention in recent years. In Ireland, the Digital Strategy for Schools to 2027 (DE, 2022) stresses the need to ensure that all students are supported to develop the skills and understanding necessary to navigate safely and productively in a digital world. This requires educators to consider their role in advocating

for the appropriate use of technology with children, and the optimal use of digital technology in classroom and early childhood settings.

Issues of access, equity, inclusion and social justice.

Issues of equality of opportunity, excellence in instruction, and social inclusion should underpin all that we do to ensure that all students, regardless of ethnicity, age, geographical location, class, gender or socio-economic status (SES), have equitable and quality access to digital technologies for literacy and learning in classrooms, homes and communities.

Scheerder et al.(2017) in a review of 126 articles, note three levels of digital divide: 1) limited internet access dependent on a range of demographic characteristics such as, SES, geography, or gender; 2) limited internet usage and skills; and 3) internet outcomes i.e. the ability to capitalise on internet usage to acquire benefits. Drawing on the definition provided by Bruno et al., 2010 (p. 27 cited in Scheerder et al., 2017), we consider the digital divide as a “a multidimensional phenomenon that includes a set of complex divides [...], caused by a variety of factors.” Despite finding an increased focus in more recent times on determinants of internet skills, uses, and outcomes, Scheerder et al., (2017) note that issues of access remain. They also argue for more research focussed on second- and third- level divide determinants such as, social (e.g. how individuals interact with others in different contexts) and cultural (e.g. cultural capital and habitus) to explain how some internet users capitalise on the benefits of internet usage and obtain more beneficial Internet outcomes than others.

A systematic review conducted by Rybakova et al. (2019) traced the implementation of Pope and Golub’s (2000) seven principles of teaching with technology over almost two decades. Of particular concern to the authors was how the integration of technology to develop digital literacy had promoted equity and social justice in teaching English Language Arts. The articles reviewed suggested some important shifts in practice over the time period and in an effort to bend “the arc towards equity in classrooms”, the authors make a number of recommendations. First, that teachers consider context to include the backgrounds of students and resources in the community. Second, the involvement of students in critiquing the origins of digital tools and issues of data privacy should be considered. Third, a heavier emphasis

should be placed on social justice theories when engaging in critical evaluation of texts.

Fourth, the involvement of students as the primary users and producers of texts.

Further, a review by Martínez-Bravo et al., (2020) noted the importance of locating digital literacy within a social framework. They argue that such positionality places the person at the centre of the opportunities offered by technology and seeks to promote social inclusion, equity, and access to knowledge. Finally, Tichavakunda and Tierney (2018) argue that: (a) race and culture are integral to research concerning digital equity and education and (b) the concept of cultural integrity has the potential to highlight how youth's digital practices can translate into digital skills with educational benefits.

In sum, issues of social justice should be central to effective technology integration and good practice in classrooms to ensure that there are “more voices, more diversity, more criticality and more seats at the table” (Yang et al, 2018, p.595) for the purposeful and meaningful integration of technologies to engage all students.

The use of Digital Technology in Early Childhood Settings and Classrooms.

Technology in children's lives has been positioned as imperative for children's later learning and to support participation in an ever changing digital world, as well as already being part of children's family practices (Kontovourki & Tafa, 2019). Children develop a range of digital literacy skills as they engage in routine activities at home and in Early Childhood Education and Care (ECEC) settings, using digital technologies for information, entertainment, creation, communication, and learning (Joint Research Centre (European Commission) et al., 2018). The age at which children first use touch screen devices is lowering (Burns & Gottschalk, 2019) and the amount of time young children spend engaged with digital technology is increasing (Goode et al., 2020; Rideout & Robb, 2020). The impact of screens has attracted negative attention in the media, and there are legitimate fears around the effect of screens on young children's health and development (Dubicka et al., 2019). Mantilla & Edwards (2019) identified concerns relating to technology use and its impact on posture, sleep, and the suitability of screen use with infants and toddlers. Therefore, modelling correct posture when using digital technology and encouraging children to balance whole body movement activities with short periods of digital technology use is recommended. Further in line with screen time recommendations (American Academy of Pediatrics, 2016 ; Canadian Paediatric Society, 2017) the authors advise the restriction of digital technology after 7pm and immediately prior to bedtime to support sleep hygiene. In tandem, video-chat with infants

and toddlers that incorporates live interactions is encouraged to “transform passive viewing experiences into socially contingent learning situations” (Roseberry et al., 2014, p.967). Digital technology is identified as a way to strengthen relationships between children, families and educators. For example, Knauf (2016) found that digital media influenced the quality and quantity of communication between parents and the setting.

All five studies reviewed by Mantilla and Edwards (2019) attempt to establish frameworks about digital play that educators can use to foster this activity in ECEC. Predictably, the ECEC setting and educator knowledge about digital technology influences how children experience and participate in digital play. Children already use digital technologies in many ways. Play can involve epistemic, spontaneous and transgressive play (children using apps in ways that contravene the intentionality of use determined by the producers) as well as other common types of play such as construction or role play (Marsh et al., 2016).

Overall, the analyses across systematic reviews showed a significant touchscreen learning effect indicating that young children benefit from touchscreen learning. Across the reviews digital devices were found to have a beneficial effect on young children's learning across a number of developmental domains. The use of technology was seen to support cognitive learning in areas including language and literacy, digital literacy, mathematics, science and general cognitive skills such as self-regulation, problem solving, creativity, self-efficacy and memory (Herodotou, 2018 ; Hsin et al., 2014; Zheng et al., 2016). These effects are mediated by a number of factors including the age of the child (effects increased with child's age), the adult role (greater vocabulary growth when adults accompanied children), design features (interactivity, narration and highlight functions, open-ended tasks, variety of representations and levels of difficulty supporting refinement of math ideas), similarity between applications and transfer context (near transfer found to facilitate learning), learning domain (benefited more when learning STEM-related knowledge vs Non-STEM (Xie et al., 2018) and access i.e. one-device-per child was observed to lead to cognitive benefits in diverse domains especially for struggling students and girls (Herodotou, 2017). However, Herodotou (2017) stresses that drawing firm conclusions in relation to mobile apps is a challenge due to the limited understanding of their impact on young children's learning and development, so these should be used with caution. Islam and Grönlund (2016) in a review of 1:1 computing in schools provide a useful summary of research regarding both the positive and the negative effects of adopting 1:1 computers in schools. Positive effects include

constructivist and positive teaching approaches, collaboration, access to online content, improved classroom dynamics, meeting of curricular goals; while the negative includes insignificant academic achievement, distractions, over-dependency, logistical and technical issues. Rather than a top down approach the authors urge that any adoption of 1:1 laptops or devices, at any level of the education system, should be preceded by a vision related to curricular goals, pedagogy, and student learning and a recognition that strong leadership of change management is needed for effective implementation.

In the social domain, studies showed that technologies enhance collaboration and interaction between children and can support children's understanding of multiculturalism (Hsin, Li & Tsai, 2014). However, studies examining possible impact of devices on social and emotional development of younger children from birth to two years were limited (Herodotou, 2017).

In sum, the way in which everyday literacy practices and communication have been transformed by technology require educators to consider their role in advocating for the appropriate use of technology with young children, and the optimal use of digital technology in classroom and early childhood settings.

Digital Literacy in the Classroom: The Role of the Teacher

The affordances provided by digital technologies lie not in the tools themselves but rather in how teachers envision the potential, possibilities, and transformational power of such tools for literacy in the classroom (Leu et al., 2018). Digital tools cannot accelerate or deepen student learning and achievement without a teacher with strong pedagogy, including the teacher's own digital competence (e.g. Røkenes & Krumsvik, 2014). Teachers' pedagogical orientations are thus pivotal in how digital technologies are used, that it is the "pedagogy of technology application rather than technology itself that makes a difference" (OECD, 2017, p.8). In classrooms, teachers must consider curriculum goals and learning outcomes for students before considering the meaningful use of technology to enhance literacy and learning in the classroom (Mishra & Koehler, 2006). In doing so, they must consider the pedagogical frameworks along with the affordances of the technology as they are designing learning activities. In this way, learning occurs at what Crompton and Burke (2020) call the 'transformational level', allowing early childhood, primary, and post-primary students the

opportunity to participate in new learning activities at a higher cognition level and to do in ways that that are inconceivable without the use of technology.

Similarly, Rybakova et al. (2019) reviewing almost 20 years of teaching with technology, note that teachers should be critical users of technologies probing not only the what and the how of using technologies but more importantly the why and the when to embed digital technologies in their classroom practices. The focus should be on technology as a literacy tool whereby teachers should use technologies not only to model reading and writing processes but also model learning to use new technologies themselves. Teachers need to create collaborative, authentic, learning environments in classrooms, engage in modelling and explicit strategy instruction of the skills and strategies that their students require and scaffold their students as they learn in digital environments. Martínez-Bravo et al. (2020) review further builds on this noting that being digitally literate enables students to perform intuitively in digital environments to easily and effectively access a wide range of knowledge embedded in those environments. Student centred rather than teacher centred approaches towards the use of technology has also been found to be more effective (Tamim et al. (2015).

Incorporating multiliteracies and multimodalities into classroom literacy practices is challenging for teachers. The review conducted by Hong and Hua (2020) revealed that teachers are facing greater challenges than never before in selecting and designing a pedagogy that can engage students in meaningful literacy practices in the sphere of technological learning. Teachers need to think creatively by considering the multimodal literacies that students are engaged with in out-of-school activities and designing pedagogic activities in the classroom that can engage students in higher levels of thinking about the nature of multimodal texts. To achieve this pedagogic goal, teachers will have to become more insightful about multimodal learning by looking at literacy in a new light. Hong & Hua, (2020) urge teachers to adopt gamified learning as a possibility of interest to both learners and teachers. Kontovourki and Tafa (2019) concur that game based learning approaches can improve both student motivation and engagement.

When compared to research on older children, understanding of pedagogical practices to support digital technology integration in ECEC remains limited (Kontovourki & Tafa, 2019). Wood et al. (2019) argue that children's digital play practices surpass educators' pedagogical practice and adaptation of curriculum to incorporate digital technologies. Further, they claim that "children's digital activities are not always well understood by

teachers, and might not be valued in ways that will advance children's competences, or connect with curriculum content" (p.214). Mantilla and Edwards' study (2019) make a number of key recommendations to help educators adapt their pedagogy to incorporate digital technologies. As with traditional resources, digital technology use should relate to children's existing interests and curriculum themes. Children benefit from using digital technology with others, thus, digital materials should be placed in the classroom in ways that promote collaboration and encourage social interaction when using digital technology. It is strongly suggested that age-appropriate software and digital technology that facilitates children's independent use of technology alongside adult interactions should be sourced. Finally, well-meaning adults can disrupt children's digital play. Therefore, appropriate time and space should be allocated to enable children to explore functionality.

In sum, teachers' pedagogical orientation and professional knowledge are pivotal to the meaningful use of technology to enhance literacy and learning in the classroom and ECEC settings. This view is supported by the DSS (DE, 2022) which commits to the provision of "flexible, differentiated, needs based teacher professional learning" (p.21) so that teachers are enabled to meaningfully use digital technologies in all aspects of teaching, learning and assessment.

Developing Digital Literacy in the Classroom: Motivation and Engagement, Reading, Writing/Communicating

The ability to communicate meaning from speaker to listener, from writer to reader from creator to viewer is enabled by digital technologies. Students need access to, acquaintance with, and ability to use technologies effectively (Tamborg et al., 2018). The sections which follow consider, in turn, motivation and engagement, reading, writing and communication using digital technologies.

Developing Digital Literacy in the Classroom: Motivation and Engagement.

Motivation and engagement emerged as a theme across all age groups (Yang et al., 2018). For example, Chen and Macleod's (2021) systematised review considers the effectiveness of digital tools to support students' reading in secondary schools. Their study illustrates how digital tools are effective in motivating adolescents' reading interest, and improving their reading skills and test scores; it also highlights that teachers are key facilitators in the process. While specifically focusing on 12-18 year-old students, the authors suggest that their findings

are in line with research with younger age-groups, suggesting the transferability of research across a wide age-range.

Reviews equally (Maas & Hughes, 2020 ; Parmaxi & Demetriou, 2020) highlight a number of potential benefits from using Augmented Reality (AR) as a tool for literacy; these include increased learner interest, motivation, satisfaction, attention, engagement and enjoyment in comparison to conventional teaching methods. The AR dataset compiled by Parmaxi & Demetriou, 2020 also reported a wide range of benefits for vocabulary acquisition, writing, reading, speaking, comprehension, pronunciation and phonics.

Significantly, a number of reviews highlight the critical understanding and representation of meaning through multiple modes and through multiple representations of knowledge using digital tools. Students' attitudes towards technology usage are also identified as a key element of increasing digital literacy. Digital skills (including social media skills and internet safety skills) and levels of knowledge (conceptual, declarative, procedural and conditional) are important to be able to access information in multiple formats, from a wide range of sources, across a range of digital devices. Social practices and classroom culture include "meaning making and participating in social practices around texts" (Tran, 2016, p.213 cited in Tamborg et al., 2018).

Developing Digital Literacy in the Classroom: Reading online and on screen.

A number of studies relating to the use of digital technologies and reading instruction have been carried out over the past three decades. According to Yang, et al. (2018), technology has served in reading instruction primarily in three ways: 1) to increase reading motivation, 2) to present information in multi-modalities, and 3) to promote collaborative learning.

Using online information to read, solve problems and learn is central to our lives (OECD, 2021). Given the complexity of online informational texts it is important that we envision reading in new ways (Kervin, Mantei & Leu, 2018). Online reading skills are built on foundational print-based skills but reading is more complex in an online environment. Leu et al., (2018) identify five practices that define online research and inquiry and comprehension processing. These include identifying a problem and generating meaningful questions for research, locating information, critically evaluating information, synthesising information across multiple sources and modes and communicating information to others. As students leverage technology for literacy and learning they access, acquire, comprehend,

analyse, evaluate, create and communicate knowledge in multiple modes and through multiple representations.

The International Literacy Association (ILA) (Literacy Glossary, n.d) stress the importance of critical thinking skills to examine how texts are constructed and produced, whose voices are heard and whose voices are silent. Gibson and Smith (2018) also emphasise the need for criticality. Their review concludes that regardless of whether a learner is a child in their first years of primary education, or an adult learner embarking on a degree programme, there is a process involved when dealing with information.

Critical evaluation of information in an online environment introduces new complexities for the reader as the Internet is an un-vetted open network where anyone can publish any information. Evaluation of online information includes critical evaluation skills, critical thinking skills, critical literacy skills, and media-savviness and information literacy skills. These skills are required to evaluate, corroborate, and interrogate the accuracy, reliability, objectivity, credibility, and veracity of information presented online (Dwyer, 2022). Students must construct meaning with, from, and against texts online. Evidence suggest (National Literacy Trust, 2018) that fake news or disinformation ¹is driving a culture of fear and uncertainty among young people about their ability to spot disinformation in an online environment. Therefore, it is important to help our students to develop the high level skills needed to develop a healthy skepticism (Leu et al., 2007) about what they read online. The High Level Group (EC, 2018) recommends a multi-dimensional approach to addressing the rise of disinformation online by incorporating a number of inter-related responses. In addition, the European Commission guidelines (EC, 2022) on tackling disinformation and promoting digital literacy skills for teachers and educators provide a range of learning objectives, pedagogical practices and hands-on activities aimed at both primary and post-primary students. The development of a coherent digital literacy strategy that includes combatting disinformation is a key priority of the DSS (DE, 2020).

Evidence suggests that increasing numbers of children are reading digitally (Clarke & Picton, 2019). Digital texts in ebook formats provide a range of multimodal scaffolds such as, hyperlinks, read aloud features, pop-up definitions which are customisable, flexible,

¹ As defined by the High Level Group (EC, 2018) "Disinformation includes all forms of false, inaccurate, or misleading information designed, presented and promoted to intentionally cause public harm or for profit "(EC, 2018, p.5)

supportive and responsive to the needs of students. Furthermore, digital texts afford readers the role of writers as they annotate or highlight passages and words and author digital thinkmarks to capture their responses as they read (Dwyer & Larson, 2014). Chen and Macleod (2021) note that digital tools are effective in motivating students' reading interests. Their findings are in line with research for younger age groups suggesting the transferability of research across a wide age range.

The development of emergent and early literacy skills using digital technologies has garnered much attention within the literature. In early literacy, gains (average positive effect size of 0.28 across treatments and outcome measures) were found in the domains of phonological awareness, letter knowledge and early reading and spelling via computer-supported early literacy interventions (Verhoeven et al., 2020)

The increased use of touch screen devices by young children in the past decade leads to the question whether paper or screen is better for children's learning. In their meta-analysis examining the effect of e-book use on literacy outcomes for students in grades k–12, Swanson et al. (2020) indicate that reading outcomes for students in grades K–6 may not differ when reading e-books or print books. However, Clinton's (2019) systematic review and meta-analysis of 33 studies investigating reading from paper compared to screens would suggest that readers may be more efficient and aware of their performance when reading from paper compared to screen. This concurs with the findings from Singer and Alexander (2017).

A number of meta-analyses on the use of print texts and digital texts were reviewed and findings across studies were fairly consistent. Text length appears to be a factor while reading on screen, causing eye discomfort for readers with prolonged exposure to screen (Çetin & Kiliçkaya, 2019). Adult mediation during print reading is more effective than digitally enhanced texts read by the child independently. However, multimedia stories were found to be more beneficial than print both for vocabulary and story comprehension when children did not have the support of an adult (Furenes et al., 2021), and were found to be particularly useful for children from disadvantaged communities (Takacs et al., 2015). Takacs et al. (2015) found a small but significant additional benefit of technology for story comprehension ($g+ = 0.17$) and expressive vocabulary ($g+ = 0.20$), based on data from 2,147 children in 43 studies.

It is generally recognised across the studies reviewed that the nature of multimedia enhancements impact children's learning. When used appropriately, features such as background music, sound effects and animated illustration were beneficial, providing scaffolding of story comprehension and word learning similar to that of an adult ((Takacs et al., 2014; 2015). In contrast, interactive elements like games, dictionaries and hotspots were distracting for young children (Takacs, Swart, & Bus, 2015). Therefore, digital enhancements must be related to the content of the story and relate to children's interests.

In sum, online reading skills are built on foundational print-based skills but reading is more complex in online and digital environments. As students leverage technology for literacy and learning they access, acquire, comprehend, analyse, evaluate, create and communicate knowledge in multiple modes and through multiple representations. Screens cannot replace interactions with an adult when reading, but multimedia books have a positive impact on children's learning when compared to children reading alone. Features of multimedia stories can have positive or negative effects. Therefore, ECE must have the skills and knowledge to evaluate these tools before introducing them in their settings.

Developing Digital Literacy in the Classroom: Writing and Communicating.

Reviews by Colwell and Hutchison (2015) and Williams and Beam (2019) show technology-mediated writing to support students' composing processes and writing skills as well as their knowledge and use of new literacies in a number of ways. Across K-12 (ECEC, primary and post-primary), students were found to design, produce, and present a variety of multimodal and digital texts that represented their knowledge and understandings of literary material. The use of digital technologies supports students' composing processes and skills, increases student motivation to engage in writing instruction and increases social interaction and peer collaboration.

Focussing specifically on primary level, Colwell and Hutchison (2015) also found that when engaged in technology-mediated writing students (a) write for more authentic purposes; (b) the inclusion of oral language activities using digital recording devices supports students' idea development and writing; (c) students have increased opportunities to interact and collaborate with peers, critically evaluate each other's work, and consider multiple perspectives; (d) students are encouraged to think about traditional content in new ways; and (e) digital tools provided insight into students' reading behaviours and comprehension. However, despite a focus on the creative potential of tools for children from 2-5 years of age,

an empirically based understanding about young children's writing on screen is not yet established (Kucirkova et al., 2019). The authors stress the need for further research to provide greater specification for the purpose of children's writing on screen and the tools and applications supporting their endeavours. They stress the need for interdisciplinary approaches to capture the composing stages involved in the writing process with and around screens. Finally, age-related differences in documenting and reporting the composing process in classrooms are noted. Kucirkova et al. (2019) further argue the need for research conducted from a critical perspective and focused more directly on multimodality

The work of (Miller, 2013) focuses on adolescents and stresses the importance of expanding the available resources for making meaning. Six emergent themes are presented in this review to develop a pedagogical framework for multimodal composing as embodied learning. They include (a) a change in teachers' stance towards a New Literacies perspective; leading to (b) the development of classroom social spaces for mediating multimodal composing ; followed by (c) the co-construction of authentic communicative purpose for representing meaning, in part by (d) opening meaning-making to student lifeworlds and cultural resources, and (e) explicitly attending to multimodal design for representing meaning, leading to (f) students' transmediating or translating in symbolic modes.

Interest in the use of social media as a tool to promote and develop literacy and in particular, writing to has grown exponentially in the last decade or so. (Barrot, 2021) extensive review of articles from 2008 to 2019 concludes that high-profile platforms such as Facebook, Skype, WhatsApp, and Twitter continue to attract the greatest attention from language learning scholars, and attributes this result to their multiple and flexible communication affordances, wide geographical distribution, and large number of active users. In their review, the authors identify 19 articles concerned with digital literacy, such as exploring literacies developed through use of Twitter; noting that these articles fit into and often reference a much larger body of research on digital literacy. Reviews by (Dennen et al., 2020) and Galvin and Greenhow (2020) focus specifically on writing on social media in classroom contexts at middle school and high school levels. Dennen et al. report ways that social media can be used to support activities, such as writing on social media platforms and recording vlogs (video blogs). Galvin and Greenhow (2020) identify a number of uses for social media, including the use of online composition spaces for formal classroom projects, as supplemental tools within a larger writing project and the use of social media for

connections to authentic contexts or to replicate real-world experiences. The authors suggest that granting students the autonomy on the chosen platform and facilitating authentic experiences for students was one of the factors that contributed to improved student writing performance, increased self-confidence and motivation to write; they also noted the central role of the teacher relating to this. Manca et al.'s. (2021) review of 54 articles from 2011 to 2019 considers a 'glocal approach' to the development of social media literacy. The authors adopt the theoretical lens of New Literacy studies to suggest a combined perspective for investigating social media literacies, which considers both social media skills that are transversal across different social media (global skills), and those that pertain to a specific social media platform (local skills). The inclusion of social media is not without challenges. These include balancing the affordances of social media's informal, social space with formal classroom expectations, and finding meaningful ways to make students' social media use authentic.

Conclusion

To conclude, it is clear from the systematic reviews and meta-analyses, (supplemented by reports and handbook chapters) reviewed for this paper that we must "educate students for their future, rather than for our past" (OECD, 2021, p.4). We need to ensure that our students develop the skills, strategies, social practices, and dispositions to optimise their use of the Internet and other digital technologies, digital tools, and digital media to enhance literacy and deepen their learning in an ever-changing world. This is complex work and teachers need to engage with professional learning opportunities that are sustained, on-site, and customized to the literacy needs of the school community. In such learning communities, teachers can develop the pedagogies and strategies required to provide the scaffolded learning environments that students require as they interact with digital technologies, multiliteracies and multimodalities in print texts, e-texts on the Internet and e-books.

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Educational Research, 86(4), 1052–1084. <https://doi.org/10.3102/0034654316628645>

Biography

Dr Bernadette Dwyer is an Associate Professor in the school of Language, Literacy and Early Childhood Education where she lectures and researches in the area of Literacy. She has published refereed articles in high ranking journals, chapters in books, commissioned reports, and has edited conference proceedings. Her most recent book publication is *Using technology to improve reading and learning*. Bernadette is a regular presenter at both national and international conferences and has given a range of invited keynote addresses at conferences around the world. Bernadette has been awarded a number of awards including the DCU President's award for Engagement in the Community(2016) and the Technology in Reading Research Award (2017) by the TILE-SIG of the International Literacy Association. Bernadette served on the International Literacy Association (ILA) board from 2013-2016 and was elected as President of ILA 2018. She chaired the International Taskforce on the systematic review of the literature pertaining to Children's Rights to Read. and Children's Rights to Excellent Literacy Instruction. Bernadette is currently engaged in research in the areas of multimodal/ digital literacies; inquiry-based learning; and disciplinary literacies.

Dr. Enda Donlon is an Associate Professor in the school of STEM Education, Innovation and Global Studies at the Institute of Education, Dublin City University. His research interests include digital learning and teacher education, with a particular emphasis on where the two intersect. Enda is a former president and vice-president of the Educational Studies Association of Ireland (ESAI) and served on the Executive Committee of the Computers in Education Society of Ireland (CESI) for over ten years.

Fiona Giblin is an Assistant Professor in Early Childhood Education at DCU Institute of Education and contributes to undergraduate and postgraduate initial teacher education programmes, as well as masters of education programmes. Fiona has previously worked as a primary school teacher and contributed to the design and delivery of continuing professional development throughout the country on Aistear, Ireland's early childhood curriculum framework. Fiona's research interests include teacher education and early childhood curriculum and pedagogy, with a particular focus on multimodal communication, meaning making and play. More information available <https://www.dcu.ie/language/literacyandearlychildhoodeducation/people/fiona-giblin>

Dr. Margaret Leahy TO FOLLOW

Sandra O'Neill (ORCID iD: 0000-0002-4271-8163) *is an Assistant Professor in Early Childhood Education in the School of Language, Literacy and Early Childhood Education in DCU's Institute of Education. Sandra lectures in early mathematics, STEM and technology in early childhood on the Bachelor of Early Childhood Education. She is the founder of the Early Childhood STEAM network and member of CASTeL, Ireland's largest research centre in Science, Technology, Engineering, and Mathematics (STEM) education. Her research interests include STEM in early childhood, non-gendered play and children's citizenship and participation. She is currently undertaking doctoral studies in the University of Sheffield with a focus on STEM policy.*

Research Questions

1. What systematic reviews or meta-analyses have been conducted that are relevant to the area of digital literacy
2. What systematic reviews or meta-analyses have been conducted to define digital literacy
3. How can learners in Primary K-6 be supported in developing digital literacy skills for reading writing and oral language
4. How can learners in early years be supported in developing digital literacy skills for reading writing and oral language.
5. How can learners in post primary be supported in developing digital literacy skills for reading writing and oral language

Key Search Terms

LITERACY or “digital literacy” or “new literacies” or “ multiliteracies” (as a Subject Heading)

2. Not Medical or systematic review (medical or health * as free text search

3.and k-12 OR elementary OR primary OR Post-primary (as a free text search)

4. AND meta-analysis OR systematic review OR best evidence (as a free text search)

OR (digital literacy Or computer literacy OR Technological literacy Or Internet literacy OR digital inclusion OR Digital Equity) AND Meta-analysis Or systematic review) AND K-12 Or Elementary Or Primary or Post-primary

Key Data Sources Consulted

Note: Literature in the systematic review should be from 2011 onwards, although reference may also be made to earlier seminal works. Examples:

- SCOPUS, EBSCO, ERIC ,WILEY
- Google Scholar (to identify articles that might not appear in a systematic review)
- Handbooks in the field published since 2011
- ‘Grey literature’ (e.g., reports published by international and national organisations/governments – UNESCO, OECD, Dept of Education, NCCA etc.)

Digital literacy; digital tools for literacy development

Review	No. of studies	Effect size (If available)	Digital Literacy	Age range	Findings
Barrot, J. S. (2021). Social media as a language learning environment: A systematic review of the literature (2008-2019). <i>Computer Assisted Language Learning</i> , 1–29. https://doi.org/10.1080/09588221.2021.1883673	396 articles		Social media	14-24 years	This study reviewed the scientific literature on social media as a language learning environment published from 2008 to 2019. Most of the studies involved secondary education students (approximately 14 to 18 years old), higher education students (approximately 17 to 24 years old), and professionals (approximately 21 years old and above). Data shows that social media platforms expand in number and popularity. Consequently, this trend has sparked the interest of educators and learners in using them for language learning as reflected in the findings of this study Findings show that this field of interest has exponentially grown since 2008 and is likely to progress in the next several years
Çetin, K., & Kiliçkaya, F. (2019). A Systematic Review of Research on Reading in English on Screen and on Paper. <i>Online Submission</i> , 61(1), 7-21.	37 articles		Screen and paper	5-71 years	Inconclusive findings. Text length appears to be a factor while reading on screen, causing eye discomfort for readers with prolonged exposure to screen. Teachers might consider developing reading skills in both environments.
Chen, D., & Macleod, G. (2021). Effectiveness of Digital Tools to Support Pupils' Reading in Secondary School: A Systematised Review. <i>International Journal of Mobile and Blended Learning (IJMBL)</i> , 13(2), 1–16. https://doi.org/10.4018/IJMBL.2021040101	10 studies	-	Digital tools for supporting reading in secondary schools	Secondary Schools, 12-18 years	Digital tools are effective in motivating adolescents' reading interest, and improving their reading skills and test scores. Teachers are key facilitators in the process. Findings are in line with research with younger age-groups suggesting the transferability of research across a wide age-range.
Clark, D. B., Tanner-Smith, E. E., & Killingsworth, S. S.	69 articles		Comparing game versus	K-16	Results indicated that digital games significantly enhanced student learning relative to nongame conditions ($g = 0.33$, 95% confidence interval [0.19, 0.48], $k = 57$, $n = 209$).

(2016). Digital Games, Design, and Learning: A Systematic Review and Meta-Analysis. Review of Educational Research, 86(1), 79–122. https://doi.org/10.3102/0034654315582065			nongame conditions		Results from value added comparisons indicated significant learning benefits associated with augmented game designs ($g = 0.34$, 95% confidence interval [0.17, 0.51], $k = 20$, $n = 40$). Effects varied across various game mechanics characteristics, visual and narrative characteristics, and research quality characteristics. Taken together, the results highlight the affordances of games for learning as well as the key role of design beyond
Clinton, V. (2019). Reading from paper compared to screens: A systematic review and meta-analysis. <i>Journal of Research in Reading</i> , 42(2), 288-325.	33 articles	Screen reading had a negative effect on performance relative to paper ($g = -.25$)	Paper and screen		A systematic review and meta-analysis. Findings were similar when analysing literal and inferential reading performance separately ($g = .33$ and $g = -.26$ respectively). No reliable difference noted for reading times ($g = 0.08$). Readers may have more accurate judgement of their performance from paper compared to screen ($g = .20$). Author concludes that readers may be more efficient and aware of their performance when reading from paper compared to screens.
Colwell, J., & Hutchison, A. C. (2015). Supporting Teachers in Integrating Digital Technology into Language Arts Instruction to Promote Literacy. <i>Journal of Digital Learning in Teacher Education</i> , 31(2), 56–63.	11 articles	N/A	Digital tool and instructional methods	K-5	Digital technology supported literacy instruction and development in the following ways: (a) Students wrote for more authentic purposes; (b) inclusion of oral language activities using digital recording devices supported students' idea development and writing; (c) students had increased opportunities to collaborate with peers, critically evaluate each other's work, and consider multiple perspectives; (d) students thought about traditional content in new ways; and (e) digital tools provided insight into students' reading behaviours and comprehension. Barriers include lack of teacher understanding about technology integration, lack of professional development, limited technology support, lack of instructional support for students (e.g. modelling)
Crompton, H., & Burke, D. (2020). Mobile learning and pedagogical opportunities: A configurative systematic review of PreK-12 research using the SAMR framework. <i>Computers & Education</i> , 156, 103945.	186 articles	N/A	mobile learning through the use of portable digital device	PK-12 (2–18 years)	The pedagogical use of mobile technologies was used to transform learning (as measured by SAMR's levels of modification and redefinition) in 54% of the studies, highest trend in secondary settings. The use of mobile technologies to augment learning occurred most frequently in the literacy studies, particularly in elementary settings. The use of mobile technologies across multiple subjects can require a large commitment of planning and time. Educators should consider the affordances of the mobile devices and the pedagogical frameworks they are using for designing activities so that more learning is happening at the transformational level, allowing students the opportunity to participate in new learning

https://doi.org/10.1016/j.comp.edu.2020.103945					activities at a higher level (Bloom's Revised Taxonomy) that are inconceivable without the use of mobile technologies.
Dennen, V. P., Choi, H., & Word, K. (2020). Social media, teenagers, and the school context: A scoping review of research in education and related fields. <i>Educational Technology Research & Development</i> , 68(4), 1635–1658. https://doi.org/10.1007/s11423-020-09796-z	62 articles	Scoping review exploring existing breadth and depth of research on social media and teenagers	Social media	Mainly middle and high school (11-18 years)	19 articles on Digital Literacy (out of 224 education-related articles) including an examination of a curriculum on professionalism for medical students that included social media use, an exploration of literacies developed through Twitter use, and a study measuring student competencies and identifying user types. Four of these studies examined privacy and safety concerns, which are a big issue for both teenagers and students in areas like medicine. These articles fit into and often reference a much larger body of research on digital literacy. 104 articles on social media as a teaching and learning tool
Furenes, M. I., Kucirkova, N., & Bus, A. G. (2021). A Comparison of Children's Reading on Paper Versus Screen: A Meta-Analysis. Review of Educational Research, 0034654321998074. https://doi.org/10.3102/0034654321998074	39 articles	N/A	Paper Versus Screen	1-8 years	Adult mediation during print reading is more effective than digitally enhanced texts read by the child independently. Texts enhanced by multimedia are more beneficial than reading print books without adult guidance. When enhancements target story content digital outperforms paper. Enhancements that do not support the storyline distract the child and diminish meaning-making. Text length is also a factor when reading on screen as longer texts cause discomfort for the reader.
Galvin, S., & Greenhow, C. (2020). Writing on Social Media: A Review of Research in the High School Classroom. <i>TechTrends: Linking Research & Practice to Improve Learning</i> , 64(1), 57–69. https://doi.org/10.1007/s11528-019-00428-9	17 articles	Thematic analysis	Social media	High school	Successful implementation of social media in the writing classroom gauged through improvement in student writing performance, increased self-confidence and motivation to write, and lessons that engaged students or made meaningful connections to the real-world. Factors that contributed to improved student learning included granting students the autonomy on the chosen platform and facilitating authentic experiences for students; teacher role key here. Challenges in implementing social media: balancing the affordances of social media's informal, social space with formal classroom expectations, and finding meaningful ways to make students' social media use authentic.

Gibson, P. F., & Smith, S. (2018). Digital literacies: Preparing pupils and students for their information journey in the twenty-first century. <i>Information and Learning Science</i> , 119(12), 733–742. https://doi.org/10.1108/ILS-07-2018-0059	Not stated	Not described in any detail	Digital literacies pupils to adults	Primary-age pupils (age 4-11) and students in HE	Educators must equip learners with the autonomy to navigate their own quests for information. Critical reading and writing are key, and with the blossom of digital resources, critique of a source is also essential. The primary school setting must prepare pupils to be enquiry-minded researchers. At HE level, institutions must refine clunky, front-end LPs and ensure that new tools are trialled and adopted where necessary to support students.
Herodotou, C. (2018). Young children and tablets: A systematic review of effects on learning and development. <i>Journal of Computer Assisted Learning</i> , 34(1), 1–9. https://doi.org/10.1111/jcal.12220	19 articles	N/A	Tablets young children	2-5	The majority of studies reported positive effects on literacy development, mathematics, science, problem-solving, and self-efficacy. Factors impacting observed effects include adult role, design features, similarity between applications and transfer context and access i.e. one-device-per child was observed to lead to cognitive benefits in diverse domains especially for struggling students and girls. Study identifies that drawing firm conclusions is a challenge. A lack of studies examining the effects of mobile devices on children younger than 2 years old and studies examining possible impact of devices on social and emotional development was observed
Hong, A. L., & Hua, T. K. (2020). A Review of Theories and Practices of Multi-literacies in Classroom: Issues and Trends. <i>International Journal of Learning, Teaching and Educational Research</i> , 19(11), 41-52.	105 articles	Qualitative descriptive analysis	Multi-literacies	Not detailed	Challenges remain in incorporating multi-literacies practice into classroom. Legitimation of young people's digital and online literacies in mainstream education is not as easy as thought. Teachers need to consider how to design pedagogic activities that can engage adolescents in higher levels of thinking about the nature of multimodal texts. Researchers have urged teachers to adopt gamified learning that could interest both the teachers and learners.
Hsin, C.-T., Li, M.-C., & Chin-Chung, T. (2014). The Influence of Young Children's Use of Technology on Their Learning: A Review. <i>Journal of Educational Technology & Society</i> , 17(4), 85–99.	87 articles	N/A	Young children	0-8 years	Technologies had positive effects on children's performance across developmental domains. Among 94 studies, 83 investigated the influence of technology on cognitive learning. Social learning is the second most frequent developmental domain emphasized by the studies (n = 19), followed by the emotional domain (n = 12) and the physical domain (n = 2). Within the 83 studies that emphasized cognitive learning, different areas of learning were supported including language and literacy (n = 47), digital literacy (n = 19), math (n = 12), science (n =

					6), and general cognitive abilities (e.g., problem solving, working memory, self-regulation, and creativity) (n = 12).
Islam, M., & Grönlund, Å. (2016). An international literature review of 1:1 computing in schools. <i>Journal of Educational Change</i> , 17(2), 191–222. https://doi.org/10.1007/s10833-016-9271-y	145 articles	Thematic analysis	1-1 devices integration	K-12	Findings summarized by four categories—students, teachers and teaching, classroom environment, and community. Implication from this literature include “1:1” cannot be the leading concept for school development; there is a need for a change to something related to the core task of school—students’ learning. The multitude of devices coming into use and the increased role of networked resources make ubiquitous computer use in schools increasingly an issue of leadership. Management of these resources and managing human resources—students and teachers.
Kucirkova, N., Wells Rowe, D., Oliver, L., & Piestrzynski, L. E. (2019). Systematic review of young children's writing on screen: what do we know and what do we need to know. <i>Literacy</i> , 53(4), 216-225.	21 articles	N/A	Young children writing on screen	2-8 years	Current empirical base on children’s writing on screen is slim. Studies that have been conducted focus on a wide range of diverse aspects of writing. Based on findings, it is difficult to generate a unified empirically based understanding about children’s writing on screen. Overall, limitations in the current evidence base highlight the need for research conducted from a critical perspective and focused more directly on multimodality.
Maas, M. J., & Hughes, J. M. (2020). Virtual, augmented and mixed reality in K–12 education: A review of the literature. <i>Technology, Pedagogy and Education</i> , 29(2), 231–249. https://doi.org/10.1080/1475939X.2020.1737210	29 articles (24AR, 3 MR, 2VR)	N/A	AR Virtual and mixed reality	elementary to HE	Key themes related to AR/VR/MR usage in K-12: (1) attitude (2) motivation (3) engagement (4) performance/learning outcomes (5) 21 st Century skills/competences such as critical thinking, problem solving, communication and collaboration. Largely positive about all of these – increases IN comparison to non-use.
Manca, S., Bocconi, S., & Gleason, B. (2021). “Think globally, act locally”: A glocal approach to the development of social media literacy. <i>Computers and Education</i> , 160.	54 articles		Social media literacy	K-12, higher and vocational education; PD;	The topic of social media literacy is still an under-researched area. This study adopts the theoretical lens of New Literacy studies to suggest a combined perspective for investigating social media literacies. Across the 54 studies, there was general lack of theoretically-based research. The results show that most of the studies consider global social media skills, while only a few examine skills sets specific to a particular social media platform. Most of the identified skills concern decontextualized practices, with very few studies emphasizing the importance of fostering situated social media practices.

https://doi.org/10.1016/j.comp.edu.2020.104025				out of school	
Mantilla, A., & Edwards, S. (2019). Digital technology use by and with young children: A systematic review for the Statement on Young Children and Digital Technologies. <i>Australasian Journal of Early Childhood</i> , 44(2), 182-195.	26 studies.	N/A	Use of digital technology in early childhood	Birth to 8 years	Findings from 4 themes suggest advice for adults working in ECEC sector about appropriate digital technology use 'by and with' young children; (1) Healthy practices (2) Relationships; digital technology use across the home and ECEC settings to strengthen relationships (3) Pedagogy: Digital technology use should relate to existing classroom themes, interests and activities; (4) Digital play: Children use digital technologies in many ways and digital play can involve epistemic, ludic, and established play types
Martínez-Bravo, M.-C., Sádaba-Chalezquer, C., & Serrano-Puche, J. (2020). Fifty years of digital literacy studies: A meta-research for interdisciplinary and conceptual convergence. <i>El Profesional de La Información</i> , 29(4), 1–15. https://doi.org/10.3145/epi.2020.jul.28	Not detailed		Digital literacy		The aim of the study was to identify the conceptual contributions of each of a range of key terms to develop an integrated conceptual framework of digital literacy. Analysis suggests that the term digital literacy is the most targeted term in the literature reviewed. The authors propose a definition of digital literacy which encompasses two perspectives (1) focusing on skills-competencies for the use of technology at the personal, professional and citizen level and (2) teaching-learning and its strategies for digital literacy both in the context of life-long learning and 21st century competencies
Miller, S. M. (2013). A research meta-synthesis on digital video composing in classrooms: An evidence-based framework toward a pedagogy for embodied learning. <i>Journal of Literacy Research</i> , 45(4), 386–430. https://doi.org/10.1177/1086296X13504867	27 articles	Not detailed	Multi-modal literacy, new literacies	11-18 years	6 themes emerged from the meta-synthesis to develop a pedagogical framework for multimodal composing as embodied learning: (a) Teacher change toward a New Literacies stance led to development of (b) classroom social spaces for mediating multimodal composing in which participants (c) co-constructed authentic communicative purpose for representing meaning, in part by (d) opening meaning-making to student life worlds and cultural resources, and (e) explicitly attending to multimodal design for representing meaning, leading to students' (f) trans-mediating or translating in symbolic modes. These pedagogical principles worked in synergy, not separately, to generate embodied learning. A central finding in the meta-synthesis was the importance of expanding the available resources for making meaning—from print text to also images, sounds, movements, and gestures.

Mirra, N., & Garcia, A. (2021). In Search of the Meaning and Purpose of 21st-Century Literacy Learning: A Critical Review of Research and Practice. <i>Reading Research Quarterly</i> , 56(3), 463–496. https://doi.org/10.1002/rrq.313	75 articles		21 st century learning	K-12	A systematic review of 75 articles revealed that 21st century skills are broader than digital skills. 21st century skills are not necessarily underpinned by ICT. Seven core skills are identified: Technical information management, communication, collaboration, creativity, critical thinking and problem solving. In addition five contextual skills are pinpointed as ethical awareness, cultural awareness , flexibility, self-direction and lifelong learning
Moya, S., & Camacho, M. (2021). Identifying the key success factors for the adoption of mobile learning. <i>Education and Information Technologies</i> , 26, 3917–3945. https://doi.org/10.1007/s10639-021-10447-w	26 articles	Concept-centric approach	Mobile learning	K-12	Factors affecting mobile learning adoption were initially grouped into two categories: hard and soft. The hard category refers to those factors that impact the learning process in a way that the institutions could manage and measure in a reasonable way. This group includes three categories of factors: technological resources, digital literacy, and pedagogical factors. Soft categories are those that mainly affect the soul and the people of the institutions. The results reveal that the soft categories are more relevant when adopting mobile learning than hard ones.
Pangrazio, L., Godhe, A.-L., & Ledesma, A. G. L. (2020). What is digital literacy? A comparative review of publications across three language contexts. <i>E-Learning and Digital Media</i> , 17(6), 442–459. https://doi.org/10.1177/2042753020946291	30 articles	Analysis and comparison of definitions	Define digital literacy	N/A	This paper analyses how the term digital literacy has been conceptualised and applied by scholars in Australia, Sweden and Argentina. In the analysis the variety of definitions across and within each context, the key tensions and challenges that emerge and the implications for digital literacy education are explored.
Parmaxi, A., & Demetriou, A. A. (2020). Augmented reality in language learning: A state-of-the-art review of 2014–2019. <i>Journal of Computer Assisted Learning</i> , 36(6), 861–875.	54 articles	N/A	AR	Preschool-tertiary	Potential benefits from using AR as an educational tool for language learning: Increased motivation, satisfaction, attention, engagement and enjoyment; closely related with students' interest and motivation to engage with a new technology and report higher levels of interest and engagement in comparison to conventional teaching methods. AR dataset reported a wide range of benefits for vocabulary acquisition, writing, reading, speaking, comprehension, pronunciation and phonics.

https://doi.org/10.1111/jcal.12486					
Røkenes, F. M., & Krumsvik, R. J. (2014). Development of student teachers' digital competence in teacher education-A literature review. <i>Nordic Journal of Digital Literacy</i> , 9(04), 250-280.	42 studies	Deductive and inductive thematic analysis	Digital competence and student teachers	Student teachers at post primary level	Digital competence is central in this review. Definition provided. Eight approaches were identified to develop student teachers' digital competence in teacher education through ICT-training: collaboration, metacognition, blending, modelling, authentic learning, student-active learning, assessment, and bridging theory/practice gap. Approaches highlight at a micro- or interactional level, what teacher education programs can focus on for facilitating ICT-training and development of student teachers' digital competence.
Rybakova, K., Rice, M., Moran, C., Zucker, L., McDermott, M., McGrail, E., Loomis, S., Piotrowski, A., Garcia, M., Gerber, H. R., Marlatt, R., & Gibbons, T. (2019). A Long Arc Bending toward Equity: Tracing Almost 20 Years of ELA Teaching with Technology. <i>Contemporary Issues in Technology and Teacher Education (CITE Journal)</i> , 19(4).			Social justice/ equity		Systematic review of how Pope & Golub (2000) curriculum standards and guidelines for the preparation of English teachers with regard to digital technology have been implemented in the intervening years. Studies suggested the need to provide a wide range of opportunities to use technology. Collaboration and connection among students was a prominent feature of many of the articles reviewed. Assessment practices were emphasised in analysing, evaluating and grading projects.
Scheerder, A., van Deursen, A., & van Dijk, J. (2017). Determinants of Internet skills, uses and outcomes. A systematic review of the second- and third-level digital divide. <i>Telematics and Informatics</i> , 34(8), 1607–1624.	126 articles		Social justice/ equity		Scheerder et al.(2017) review of 126 articles, note three levels of digital divide: 1) limited internet access dependent on a range of demographic characteristics such as, SES, geography, or gender; 2) limited internet usage and skills; and 3) internet outcomes i.e. the ability to capitalise on internet usage to acquire benefits.

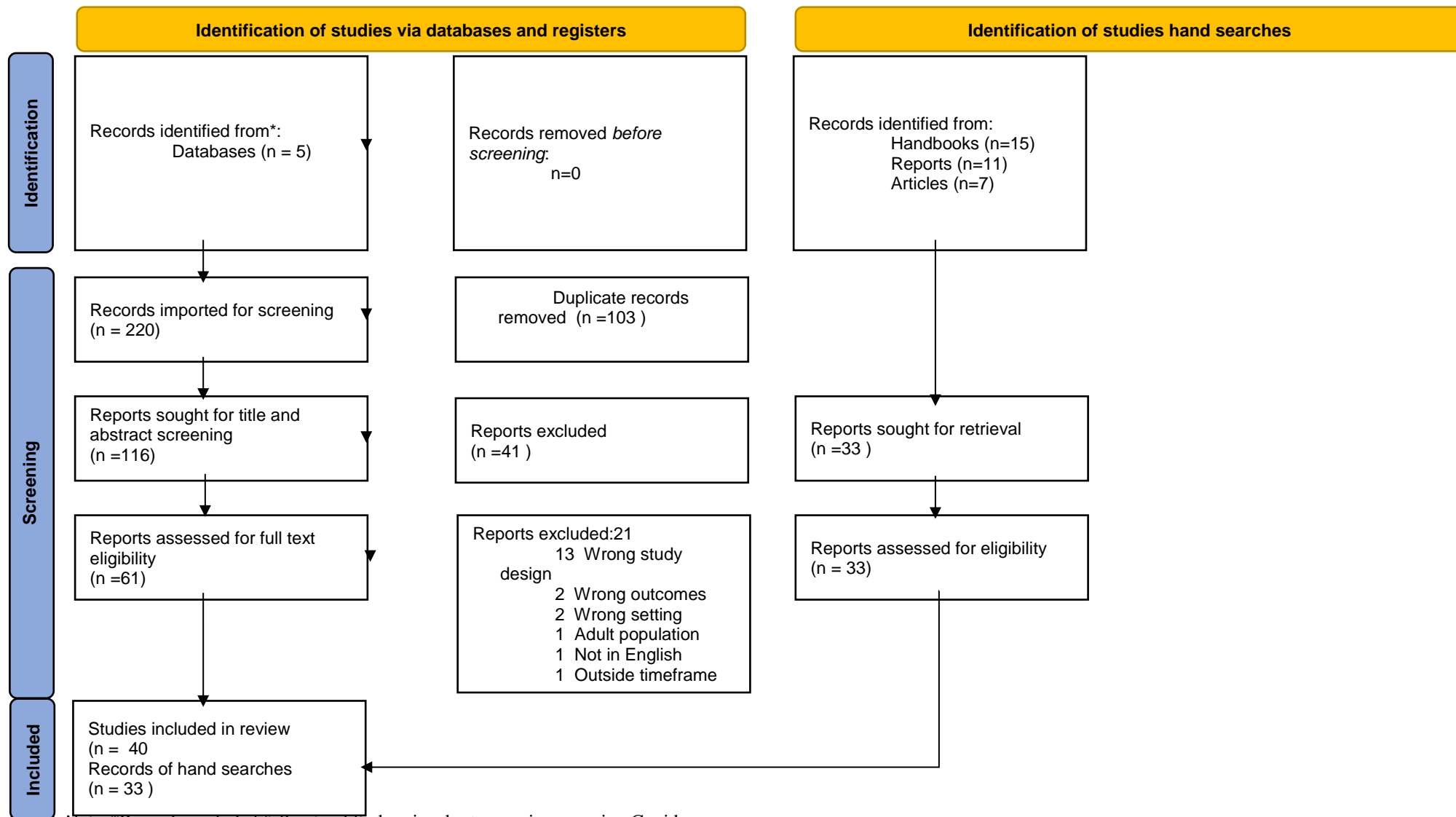
<p>https://doi.org/10.1016/j.tele.2017.07.007</p>					
<p>Singer, L. M., & Alexander, P. A. (2017). Reading on paper and digitally: What the past decades of empirical research reveal. <i>Review of educational research</i>, 87(6), 1007-1041.</p>	<p>36 articles</p>		<p>Paper and screen and</p>	<p>Undergrad students</p>	<p>Study investigating the effects of processing texts in print or digitally on readers' comprehension, processing time and calibration. Comprehension was tested at three levels-main ideas, key points and other relevant information. Processing time significantly affected the relationship between medium and comprehension at all three levels. Performance was better with print texts. Students read more quickly and judged their performance as higher when reading in a digital format.</p>
<p>Swanson, E., Austin, C. R., Stewart, A. A., & Scammacca, N. (2020). A Meta-Analysis Examining the Effect of E-Book Use on Literacy Outcomes for Students in Grades K–12. <i>Reading & Writing Quarterly</i>, 36(5), 480–496. https://doi.org/10.1080/10573569.2019.1696724</p>	<p>14 articles</p>	<p>Average effect size across all studies of 0.9 that did not differ significantly from zero.</p>	<p>E-books</p>	<p>K-12</p>	<p>Some evidence that reading outcomes for students in grades K–6 may not differ when reading e-books or print books. There was also no statistically significant difference between e-book and non-e-book conditions on measures of reading comprehension.</p>
<p>Takacs, Z. K., Swart, E. K., & Bus, A. G. (2014). Can the computer replace the adult for storybook reading? A meta-analysis on the effects of multimedia stories as compared to sharing print stories with an adult. <i>Frontiers in Psychology</i>, 5.</p>	<p>29 articles</p>	<p>Multimedia stories more beneficial than traditional when adult support</p>	<p>Multi-media vs print stories</p>	<p>Pre-K to elementary</p>	<p>Multimedia stories were found to be more beneficial than traditional print story books where adult was not present, both for vocabulary and story comprehension. The study concludes that features such as background music/ sound effects and animated illustrations provide similar scaffolding of story comprehension and word learning as an adult. No significant differences found between the learning outcomes of sharing traditional print story books with an adult and multimedia stories.</p>

https://doi.org/10.3389/fpsyg.2014.01366		not included (g+ = 0.40, k = 18)			
Takacs, Z. K., Swart, E. K., & Bus, A. G. (2015). Benefits and pitfalls of multimedia and interactive features in technology-enhanced storybooks: A meta-analysis. <i>Review of educational research</i> , 85(4), 698-739.	43 articles	benefit of technology was found for story comprehension (g+ = 0.17) and expressive vocabulary (g+ = 0.20)	Interactive features of e-books and multimedia	Young Children	A meta-analysis was conducted on the effects of technology-enhanced stories for young children's literacy development when compared to listening to stories in more traditional settings like storybook reading. When investigating the different characteristics of technology-enhanced stories, multimedia features like animated pictures, music, and sound effects were found beneficial. Interactive elements like hotspots, games, and dictionaries were found to be distracting. Especially for children disadvantaged because of less stimulating family environments, multimedia features were helpful and interactive features were detrimental
Tamborg, A. L., Dreyøe, J. M., & Fougst, S. S. (2018). Digital literacy—A qualitative systematic review. <i>Tidsskriftet Læring Og Medier (LOM)</i> , 11(19), 29–29. https://doi.org/10.7146/lom.v11i19.103472	55 articles	N/A	Defining digital literacy	Elementary and primary education	The complexity of digital literacy and the many actors and contexts is alluded to with a broad variety in how digital literacy is defined and used in the research literature in the context of elementary and primary education. There might also be advantages of making efforts in maintaining and perhaps continuing to broaden our perspectives on digital literacy. Three potential sources of these varieties: The various topics that digital literacy is related to, the fact that digital literacy is often not defined or substituted with another similar term, and that established definitions of digital literacy are combined with theories from other fields. Using the model below with the dimensions of interpersonal/intrapersonal and technology-centric /human-centric can be used to map the definitions and usages of digital literacy and describe how they relate to each other.
Tamim, R. M., Borokhovski, E., Pickup, D., Bernard, R. M.,	68 articles	A significant	Tablets	1st to 3rd level	Qualitative literature review revealed that tablets and smart mobile devices are garnering positive perceptions within educational contexts, with the strongest support showing for the

<p>& El Saadi, L. (2015). <i>Tablets for Teaching and Learning: A Systematic Review and Meta-Analysis [Report]</i>. Commonwealth of Learning (COL). http://oasis.col.org/handle/11599/1012</p>		<p>nt average effect size found for studies comparing tablet use contexts with no tablet use contexts (g+ = 0.23, k = 28).</p>		<p>education</p>	<p>technologies' effectiveness in particular tasks and when used within more student-active contexts. Advantages include that they: improved students' organisational and note-taking skills; enhanced students' ability to express themselves and their understanding in creative ways; supported students' independence and communication skills; increased students' accessibility to resources while supporting complex visualisation of concepts; and improved students' literacy and math skills Challenges included: the technical issues the devices can have and the expertise needed for their use; the distracting nature of the devices and the plethora of apps; and the pressing need for professional development to enable teachers to properly integrate the device into the teaching and learning process</p>
<p>Tichavakunda, A. A., & Tierney, W. G. (2018). The "Wrong" Side of the Divide: Highlighting Race for Equity's Sake. <i>Journal of Negro Education</i>, 87(2), 110–124.</p>	<p>34 articles</p>		<p>Social justice/ equity</p>		<p>With a greater understanding of the educational implications of how Black youth use digital media this paper argues scholars and practitioners have the potential to play to students' strengths in developing digital literacy. Based on a systematic review of literature, the authors' argument is two-fold: (a) race and culture are integral to research concerning digital equity and education and (b) the concept of cultural integrity has the potential to highlight how youth's digital practices can translate into digital skills with educational benefits. This knowledge, in turn, has the capability to influence how schools, colleges, and universities use digital and social media.</p>
<p>van Laar, E., van Deursen, A. J. A. M., van Dijk, J. A. G. M., & de Haan, J. (2017). The relation between 21st-century skills and digital skills: A systematic literature review. <i>Computers in Human Behavior</i>, 72, 577–588. https://doi.org/10.1016/j.chb.2017.03.010</p>	<p>75 articles</p>		<p>21st century skills</p>		<p>21st century digital skills drive organisations' competitiveness and innovation capacity. 21st century skills are broader and more often at the conceptual level than digital skills. The review identifies seven core skills: technical, information management, communication, collaboration, creativity, critical thinking and problem solving. Five contextual skills were also identified: ethical awareness, cultural awareness, flexibility, self-direction and lifelong learning.</p>

Verhoeven, L., Voetena, M., van Settena, E. & Segersa, E. (2020). Computer-supported early literacy intervention effects in preschool and kindergarten: A meta-analysis. <i>Educational Research Review</i> , 30 (2020) 1003252. https://doi.org/10.1016/j.edurev.2020.100325	59 studies	Average positive effect size of 0.28 across treatments and outcome measures	Computers and early literacy	Pre-school and K	Computers can have a beneficial effect on young children's learning in the domain of early literacy. Substantial gains were found in the domains of phonological awareness, letter knowledge and early reading and spelling via computer-supported early literacy interventions. Findings indicate that the use of educational technology can be more effective when the materials are better integrated and consistent with the curriculum, and provide ongoing scaffolding for each learner.
Williams, C., & Beam, S. (2019). Technology and writing: Review of research. <i>Computers & Education</i> , 128, 227–242. https://doi.org/10.1016/j.compedu.2018.09.024	29 articles	N/A	Technology and writing		Technology-mediated writing instruction yielded improvements in students' composing processes, writing skills and knowledge and use of new literacies. Students designed, produced, and presented a variety of multimodal and digital texts that represented their knowledge and understandings of literary material and contemporary social justice issues. Relevant, high-quality teacher professional development on pedagogical uses of technology are urgently needed. Institutional support is needed to ensure the availability of computers and appropriate applications in every classroom.
Xie, H., Peng, J., Qin, M., Huang, X., Tian, F., & Zhou, Z. (2018). Can Touchscreen Devices be Used to Facilitate Young Children's Learning? A Meta-Analysis of Touchscreen Learning Effect. <i>Frontiers in Psychology</i> , 9. https://doi.org/10.3389/fpsyg.2018.02580	36 articles	Significant touchscreen learning effect (d = 0.46). 65 of 79 positive effect sizes (82.3%).	Touch screen devices	Birth-5 years	The overall analysis showed a significant touchscreen learning effect indicating that young children benefit from touchscreen learning. Learning domain (benefited more when learning STEM-related knowledge vs Non-STEM), age (effect increased with child's age), and experimental environment (better in classroom than a learning lab for example) significantly moderated the effect of touchscreen devices on learning outcomes.
Yang, X., Kuo, L.-J., Ji, X., McTigue, E. (2018). A critical examination of the relationship among research, theory, and	70 articles	N/A	Theory /practice	K-12	Technology has served in reading instruction primarily in three ways: 1) to increase reading motivation, 2) to present information in multi-modalities, and 3) to promote collaborative learning. Theories guiding the use of technology for reading instruction include sociocultural perspectives (33%), reading motivation theory (30%) social constructionism (27%) and dual

<p>practice: Technology and reading instruction. <i>Computers & Education</i>, 125, 62–73. https://doi.org/10.1016/j.compedu.2018.03.009</p>					<p>coding (25%). However, these theories were implicitly rather than explicitly stated suggesting a disconnect between theory and practice.</p>
<p>Zheng, B., Warschauer, M., Lin, C.-H., & Chang, C. (2016). Learning in One-to-One Laptop Environments: A Meta-Analysis and Research Synthesis. <i>Review of Educational Research</i>, 86(4), 1052–1084. https://doi.org/10.3102/0034654316628645</p>	<p>65 articles / 31 doctoral thesis</p>	<p>Significantly positive average effect sizes</p>	<p>laptop programmes</p>	<p>K–12</p>	<p>The most common changes noted in the reviewed studies include significantly increased academic achievement in science, writing, math, and English; increased technology use for varied learning purposes; more student-centred, individualized, and project-based instruction; enhanced engagement and enthusiasm among students; and improved teacher-student and home-school relationships.</p>



Note. *Records excluded following blind review by two reviewers using Covidence

Note. *Databases Ebsco, Eric, Google Scholar, Scopus, Wiley

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