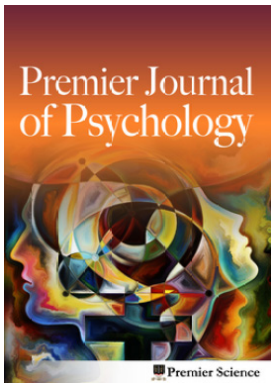

The Impact of Digital Technology on a Child's Cognitive and Social Development: Implications for Education

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ABSTRACT

Unlike in the previous generations, children now grow up with digital technologies around them, which they naturally learn to use, earning them the term "digital natives." This review looks at the influence of digital technologies on the cognitive and social development of children, with particular interest in its implications for learning and education. While the adoption of digital technologies has enabled personalized learning and ease of access to learning materials, they also pose challenges, including screen overuse, quality of content, equitable access, and others. To assess the impact of digital technologies on children's development, this review examines various studies, especially those focused on different pediatric age groups and the different forms of digital technology. Findings revealed that the use of digital technology by children has a dual effect on their cognitive and social development, with the resultant effect being dependent on factors like quality of content, duration, and pattern of use. The cognitive benefits of digital technology use by children include the development of analytical and critical thinking skills, enhanced memory retention, and language acquisition. The social benefits are that they learn to collaborate and gain exposure to a broader range of experiences and lifestyles than they would otherwise encounter. The negative effects are increased risks of social isolation, shorter attention spans, and a decline in face-to-face interactions. The implications of all these on education include the need to incorporate digital literacy into school curricula and to train teachers to be proficient and able guides for children. Using the findings from the review, recommendations were made for parents, educators, and policymakers on how to enhance cognitive and social development despite the adoption of digital technology.

Keywords: Digital natives, Cognitive development, Social isolation, Educational apps, Game-based learning

Introduction

Nowadays, children are introduced to digital technologies before they learn to talk or crawl. Chances are that their birth was recorded using a smartphone, and their developmental milestones were captured using digital technologies. Almost every child in the United States has access to the internet in their homes.[1] Traditional media, like television and radio, are gradually getting replaced by interactive digital technologies that offer instant access to information and entertainment. New applications, platforms, and technologies are emerging at a pace researchers and tech-savvy individuals find difficult to keep up with.[2]

As much as the current digital technologies offer opportunities for personalized learning and global connection, they also present challenges such as excessive screen time, questionable content quality, and unequal access across socioeconomic classes. These downsides have sparked ongoing debates and research regarding the impact of digital technology on children's development, particularly given their rapid growth and limited ability to make well-informed decisions.

Some research studies support the use of digital technology and its capacity to boost cognitive abilities. Others, such as a report published in *Pediatrics*, indicate that increased screen exposure may be linked to reduced attention span and impaired language development in young children.[3] Results of studies on the effect of digital technology on social development present a similar picture. Digital technologies enable children to connect with their peers and improve their communication skills. However, excessive online interactions may impede the development of social skills, increase the risk of social isolation, decrease empathy, and increase aggression in person if not properly moderated.

This review aims to understand the influence of digital technologies on two developmental domains (cognition and social) across different pediatric populations from infancy (0–1 year) to older children (6–12 years) and examine how these influences impact education.

Examples of Digital Technology

Educational Apps and Software

These are applications that support a learning goal, be it the learning of shapes or the mastery of new words.[4] Examples of such apps include Duolingo and Khan Academy, which teach different subjects, including languages, mathematics, and science. Storytelling apps like Epic! aim to improve literacy skills by combining engaging narratives with interactive features. Educational apps can teach children literacy skills, even before the start of school.[5] Some scholars refer to educational software as platforms. A platform is the aggregation of software applications that educators and educational systems increasingly depend on to collect and analyze classroom data; deliver, supplement, and personalize course content; assess and measure learning outcomes; monitor student behavior; and communicate with parents and guardians.[6]

Tablets and Mobile Devices

Tablets and iPads are the most common digital devices used by children. Devices like Amazon Fire Kids tablets have pre-installed educational content and parental controls. Tablet use in classrooms can

increase motivation and facilitate learning, especially for children with diverse educational needs.[7] However, concerns remain about the overuse of these devices, especially regarding their impact on attention span. A survey of adolescents without symptoms of ADHD at the start of the study indicated a significant association between increased use of digital media and symptoms of ADHD after 24 months of follow-up.[8]

Video Games and Gamified Learning

Video games, both educational and recreational, occupy a good proportion of the time children spend on digital technologies. Games like Minecraft Education Edition teach children concepts like geometry and engineering through experimentation in a virtual environment. Similarly, games like *Prodigy* make learning mathematics enjoyable through gamification. Educational video games encourage problem-solving and collaboration while helping children grasp abstract concepts.[9] Game-based learning, along with digital game design and development, is now considered essential in the educational context.[10] A meta-analysis showed the importance of game-based interventions for cognitive development.[11] Games employ powerful structural elements (i.e., rules, goals and objectives, feedback, challenges, interaction, and story)[12] that attract, engage, and motivate children. Despite these benefits, critics caution that excessive gaming may discourage real-world interactions and physical activities. Also, some argue that frequent gaming may increase dependency on external rewards.[13]

Virtual Reality (VR) and Augmented Reality (AR)

Some schools now incorporate virtual and AR technologies into their teaching models. Rather than just reading about history or science, children can now experience these subjects. These virtual adventures make students better at thinking and pique their interest in STEM subjects.[14] However, the considerable cost of VR equipment and the need for technical proficiency are significant barriers to adoption.

Communication Platforms

Digital technology facilitates communication and connection. Due to the effect of the COVID-19 pandemic and consequent social distancing on education, children learned to communicate, collaborate, and attend virtual classes with their classmates on apps like Zoom and Google Meet. These tools helped to keep learning going, which is commendable. But there are downsides. Too much screen time can make it more difficult for kids to learn how to talk and interact with people face-to-face.[15]

Artificial Intelligence (AI)

This computer science specialty designs systems that can perform tasks requiring human-like intelligence.[16] Examples are virtual assistants such as Siri and Google Assistant, large language models like ChatGPT, and many other AI-enabled applications.[17] Even infants have access to these AI-enabled applications.[18] While the public is excited about using AI in educational settings, various voices call for a cautious approach to adopting language models, stating concerns regarding output quality, usefulness, privacy, and ethical issues. Students may get into the habit of quickly generating assessed work rather than going through the learning process, subsequently resulting in the loss of critical thinking.[19]

How Digital Technology Impacts the Cognitive Development of Children

Cognitive development refers to intellectual growth.[20] This is a steady increase in a child's ability to acquire, consolidate, retrieve, and apply knowledge. There is a rapid increase in overall brain size from birth, with the brain reaching 80–90% of adult volume by age two.[21,22] Childhood is a critical time for cognitive development; hence, the impact of digital technologies on cognitive development is of interest to parents, educators, policymakers, and others.

Merit

Critical thinking skills are one of the benefits of incorporating digital technology into education. A study showed that children who used computers and other technologies in school had better critical thinking skills.[23] Another study revealed that children who played educational games performed better at solving problems compared to children who did not. These games encouraged children to think critically and make decisions, which resulted in brain growth.[12] Technology makes learning languages easier and more fun. Apps like Duolingo and Rosetta Stone adapt to the learner's pace and provide instant feedback. These apps, especially those that are interactive, can help young learners learn and remember new words.[24] Digital technology can also enhance children's memory retention. Apps like Kahoot! and Quizlet use games to help children learn through repetition and quizzes. According to Mayer's cognitive theory of multimedia learning, when text, sounds, and pictures are combined, it engages different parts of the brain and helps kids remember things better.[25]

Demerit

Research studies have well documented the concerning impact of digital technology, which is its ability to lead to attention deficits. Prolonged exposure to fast-paced content, common on many digital platforms, reduces children's ability to concentrate and sustain attention in traditional learning environments.[26] Furthermore, creativity may suffer when children become too dependent on structured apps because replacing unstructured play with screen time stifles imagination.[27]

How Digital Technology Impacts the Social Development of Children

Social development is the process by which a child learns and develops the social and emotional skills that are necessary to interact and form meaningful relationships with others. It covers learning how to communicate, cooperate, resolve conflicts, and understand social and cultural norms. Several factors

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known to influence the social development of children include family interactions, peer relationships, cultural environment, and, most importantly, in this era, exposure to digital technology. The influence of digital technology on social development is still being studied.[28] Because these devices are emerging at a rapid pace, sufficient and thorough research is yet to be conducted to reveal the impact of technologies on the development and social skills of children. This section, however, examines the possible outcomes of digital technology use in the social development of children.

Merit

A study showed that digital tools outperformed traditional teaching methods when it came to building teamwork and problem-solving skills.[29] Games that kids play together, like Minecraft and Roblox, can help forge real friendships and community bonds among older children. These games encourage skills like negotiation, conflict resolution, and teamwork to achieve common goals.[30] School platforms like ClassDojo and Google Classroom encourage kids to talk to each other and have discussions. Social media apps like TikTok, Snapchat, and Instagram can help teens make and keep friends. Using social media in moderation can make teenagers feel better about themselves. It also helps them understand other people's points of view by showing them different perspectives.[31]

Demerit

Inappropriate use of digital technologies can impede social development. When children spend excessive time on screens instead of interacting face-to-face, they miss the opportunities to learn social skills like reading body language and active listening, which weakens their ability to form real connections. A longitudinal study linked prolonged screen time with loneliness and lower levels of social well-being among adolescents.[32] Social media platforms and messaging apps can expose children to negative peer pressure, which can affect their self-esteem and lead to anxiety or depression. Children who face cyberbullying often pull back from social activities, which makes it even more difficult for them to develop friendships and social skills.[33]

There is a concept referred to as "phubbing." This occurs when children prioritize the use of their mobile devices over engaging in physical interactions. Behaviors like this can create rifts in family relationships and friendships.[34] The overuse of texting and online messaging tends to result in shallow conversations. It limits children's ability to express emotions and resolve conflicts effectively. Although digital chats are convenient, they do not have the same emotional depth and empathy present in physical conversations. This might make it more difficult for kids to develop good social skills and emotional intelligence.[35]

How Digital Technology Affects Different Pediatric Age Groups

The effects of digital technology on children's cognitive and social development differ across pediatric age groups. Children of different ages have unique developmental needs and milestones that influence how they use and benefit from digital tools. Understanding these variations is key to adapting digital experiences to support positive outcomes at each stage.

Infants (0–12 Months)

While infants do not actively use digital devices, they are often around adults who do. This can be problematic. When caregivers are frequently distracted by their devices, it disrupts the bonding time between parent and child, potentially affecting how securely attached babies feel to their caregivers, a concept called "technoference."[36] The research studies on this are unambiguous: there are no educational benefits to exposing infants to screens. These early months are necessary for forming healthy and secure bonds with caregivers; this happens best through face-to-face interaction. There should be zero screen time for babies under 18 months, except for video chats with family members, which can help maintain important family bonds.[3] This is because infants are unable to learn from screens the way they learn from real-world interactions.[37]

Toddlers (1–3 Years)

Toddlers begin to actively engage with digital technology by using touchscreens and applications designed for early learning. This can yield positive results when they use high-quality apps with their parents' involvement.[38] It has been proven that interactive content and applications with simple stories and repetitive elements can develop their growing vocabulary. However, a study revealed negative connections between tablet use and sleep. For every extra hour a toddler spends on tablets, they lose about 15.6 minutes of total sleep. To be specific, they lost 26.4 minutes of nighttime sleep while napping 10.8 minutes more during the day.[39] Apart from distorting sleep patterns, excessive screen time during this period of rapid brain development can hinder language acquisition. A study showed that toddlers who spent more than an hour a day with screens talked less and interacted less with their parents compared to other children their age.[40]

Preschoolers (3–5 Years)

Educational programs like PBS Kids and interactive storybook apps can effectively teach early reading and math skills. Children who engaged with educational content understood letter sounds and counting better than those who watched pure entertainment.[41] However, many modern children's programs are overly stimulating, with fast-paced scenes and bright, flashing colors. Later on, this might shorten their attention span, impair self-regulation, and the ability to control their behavior.[42]

Older Children (6–12 Years)

By elementary school, children can handle more sophisticated digital tools. Using educational technology thoughtfully at this age can result in improved critical thinking and the ability to collaborate with others.[43]

Nevertheless, using social media during this period can worsen feelings of inadequacy and low self-esteem.[44]

The Implications of Digital Technology for Education

The United Nations is working toward achieving inclusive, equitable, quality education by 2030.[45] Educational technology serves as a vital resource for personalizing instruction and meeting diverse student needs, which helps create more equitable learning outcomes and inclusive classroom environments.[46,47] Over the past decades, digital technology has become widely incorporated into education and is being applied in different ways, some of which have been mentioned earlier. The incorporation of digital technology in education was further accelerated by the COVID-19 pandemic, which peaked in 2020. During this period, schools, institutions, and other physical learning spaces were closed globally. This affected about 94% (1.6 billion) of the world's student population,[48] heralding a large-scale transition to online learning. Online learning offers students the chance to participate in learning at any time and in any place.[49]

Many countries and supranational organizations, such as the European Union, in a bid to develop a tech-driven workforce, have included policies to ensure that every student has access to a computer at all times.[50] Incorporating digital technology into education has so many merits. Digital technology enables adaptive and personalized learning experiences. It provides personalized feedback, guidance, and support to students. These adaptive learning systems structure the student's learning process based on their performance and progress.[51] Children engage and interact more during the learning process, and students are provided opportunities to learn through resources delivered in various forms. Also, educational technologies defy geographical boundaries, so children can learn from tutors in any part of the world, and this allows them to follow their dreams regardless of their prevailing immediate circumstances.[52,53] The use of digital technology platforms for administration, instruction, and learning produces data that can be mined to uncover patterns and insights to improve efficiency and equality in schools.[6]

Incorporating technology into education ensures that children will grow into adults who have the requirements to succeed in the modern world.[54] Integrating technology into education is a need we cannot ignore.[55]

How to Mindfully Incorporate Digital Technology into Education

Educators must wisely incorporate digital technologies into learning frameworks in ways that allow children to collaborate and think critically. To achieve this, digital technologies must be rooted in sound pedagogical principles and capable of strengthening critical thinking. It is recommended that they incorporate these four pillars in their design: active or minds-on learning, engaging content that encourages children to learn and play for longer periods, meaningful experiences that bridge the gap between the content and children's existing knowledge and finally, social interaction, to enable children to interact and socialize with others through the platform.[4]

Playful activities generally captivate children. Teachers and creators of educational technologies are to maximize this and ensure that these educational applications are equally fun and educative.[56,57]

There is a move away from "one style fits all" to a more personalized method of teaching.[58] Interactive and adaptive learning environments like Khan Academy and DreamBox Learning provide personalized learning experiences made to suit each child's pace and skill level. This method makes students learn better by targeting individual learning gaps.[59]

The collective power of minds working together in collaborative learning creates both intellectual growth and social engagement. Students develop deeper understanding through shared exploration and feedback. This collaborative approach can be implemented online through group discussions, projects, and peer activities.[60–62]

Gamification is another strategy for integrating digital tools into education. It is the process of including game mechanics like the use of leaderboards, point scoring, and rewards in educational activities. Apps like Prodigy, Kahoot!, and Classcraft implement these techniques. Gamification increases motivation and retention, particularly for younger children, because it combines educational content with elements of play.[63] However, learning activities should match students' age and abilities since overly difficult tasks can lead to disengagement or random guessing rather than genuine learning.[57]

Finding the balance between using computers and traditional teaching methods is essential. Students learn better when they combine online learning with face-to-face instruction rather than just doing one or the other.[64] While online learning is commendable, it should not completely replace activities like group work and hands-on activities. Blended learning, which combines online learning with in-person teaching, is a great way to find that balance. Means et al., in their study, opined that students in blended learning programs do better than those who learn only online or only in the classroom.[64]

Policies to Optimize Technology Use

The responsible use of digital technology in education requires clear policies that prioritize developmental and educational goals. While schools cannot be compelled to use technology in particular ways, governments have long assumed a key role in providing leadership on technology issues. It is common for governmental departments of education to include specialist technology teams and divisions, with some countries choosing to establish separate specialized agencies. For example, the U.S. Federal Government established its Office of Educational Technology in 1993. Comparable offices, agencies, divisions, and foundations have been established by federal and state governments around the world.[65] Policies on

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incorporating technology into education should be proactive. As technology evolves, education must keep pace to maximize new opportunities. When it falls behind, technology, not educators, shapes learning. Researchers, educators, policymakers, and digital designers should take the lead rather than be left behind.[66]

Policymakers may struggle to integrate digital technologies within current education systems but already, there is a framework for digital education policies along eight dimensions.[67]

Of the eight analytical dimensions, funding and procurement are very important as they partly address the digital divide. The World Telecommunication Development Report found that despite increased connectivity in developing nations, the global digital divide is widening. This divide reflects unequal access to technology and the internet, disadvantaging low-income and rural students in digital learning. Studying this gap helps policymakers allocate resources effectively, supporting schools and communities in need. Evidence-based research can guide policies that ensure equitable access to technology, giving all students a fair chance to succeed in the digital age.[68,69]

It has been found that teachers who feel comfortable with technology use it more effectively in the classroom.[70] Various theoretical frameworks have been proposed to guide the integration of technology in teacher education. The Technological Pedagogical Content Knowledge (TPACK) framework, for instance, emphasizes the intersection of technology, pedagogy, and content knowledge. Studies have shown that teachers who possess a strong TPACK are more likely to successfully integrate technology into their teaching practices.[71] Digital literacy is about giving children the tools to differentiate real information from misinformation in an increasingly complex online world. This is because children might be comfortable using digital devices, but true digital literacy requires more than just tech skills. That is why there are now guidelines to help governments protect children and teach them to be responsible digital citizens.[72]

Keeping up with educational technology might be challenging, but its significant benefits for learning make it essential for educators and leaders to overcome these hurdles and use technology to create better learning opportunities for students.[73]

Research Recommendations

Studies on the long-term effect of digital technology on the cognitive and social development of children are rare. Most research is focused on immediate outcomes. Though the foundational patterns of children's adaptation to technology have been established,[74] we lack a comprehensive understanding of how early digital habits shape later development. Hence, there is a need for longitudinal studies to explore these long-term effects and provide answers. Additionally, there is a need for intersectional studies on how socioeconomic and family contexts affect how children interact with digital technologies and the outcomes.

Research revealed troubling disparities in both access to and use of educational technology.[75] These findings suggest we need more nuanced studies of how family background, cultural factors, and parental involvement affect digital learning outcomes.

Emerging technologies such as virtual and AR present new research challenges. They are becoming more popular, yet little is known about their developmental effects. Although VR can enhance spatial thinking,[14] questions about its potential negative impact remain unanswered.

The relationship between screen time and child development requires more research. Though a study highlighted the need to understand what they termed the "dose-response" relationship—how varying levels of technology use affect different aspects of development,[40] we need clearer evidence about optimal exposure across age groups.

Recommendations for Caregivers

The AAP guideline recommends no screen time before 18 months (except video chats) and a 1-hour daily limit for children aged 2–5 years. This is a helpful starting point for caregivers who must carefully and proactively consider how to manage screen time in children's lives. It is recommended that recreational screen time for kids aged 5–17 should be limited to under two hours. This will ensure that children stay physically active and engaged.[76]

Caregivers should actively guide children on how they interact with digital technologies. This will help children go beyond being passive viewers to critically interrogating and actively engaging the information from these platforms, which makes for a better learning experience and growing ability to decide what is good or bad content.

Caregivers should not just set rules; they should create environments where real connections can be forged. There is a need for tech-free spaces and moments where children are not allowed to use mobile devices or other digital technologies. For example, family meals and bedtime routines should be free from digital interruptions. These healthy boundaries will create opportunities for real connection and better sleep patterns.

Conclusion

Digital technology, at its core, is of a neutral value. Its effects on children's cognitive and social development depend on how it is utilized. When applied thoughtfully, it can help bridge educational gaps and overcome socioeconomic barriers. Conversely, excessive or irresponsible use shortens attention span and negatively affects the development of social skills.

Policy is essential in maximizing the advantages of digital technology. Governments, educators, and industry leaders need to develop frameworks that guarantee equitable access, protect privacy, integrate digital literacy into school programs, and invest in teacher training to empower educators to guide students in its responsible application.

Creators and developers of digital tools and applications should focus on research and evidence-based design, ensuring their innovations align with developmental principles. This approach can lead to resources that not only entertain but also promote cognitive and social growth, making technology a positive influence in children's lives.

References

1 National Center for Education Statistics. Children's Internet Access at Home. Condition of Education. U.S. Department of Education, Institute of Education Sciences. 2023 [cited 2024 Dec 13]. Available from: https://nces.ed.gov/programs/coe/indicator/cch
2 Ali M, Aini MA, Alam SN. Integrating technology in learning the madrasah: Towards the digital age. Indones J Educ. 2024;4(1):290–304.
3 Chassiakos YR, Radesky J, Christakis D, Moreno MA, Cross C, Hill D, et al. Children and adolescents and digital media. Pediatrics. 2016;138(5):e20162593.
4 Hirsh-Pasek K, Zosh JM, Golinkoff RM, Gray JH, Robb MB, Kaufman J. Putting education in "educational" apps: Lessons from the science of learning. Psychol Sci Public Interest. 2015;16(1):3–34.
5 Amorim NA, Jeon L, Abel Y, Albuquerque EXS, Soares M, Silva VC, et al. Escribo play learning games can foster early reading and writing for low-income kindergarten children. Comput Educ. 2022;177:104364.
6 Nichols TP, Dixon-Román E. Platform governance and education policy: Power and politics in emerging edtech ecologies. Educ Eval Policy Anal. 2024;46(2):309–28. https://doi.org/10.3102/01623737231202469
7 Cristia J, Ibarraran P, Cueto S, Santiago A, Severin E. Technology and child development: Evidence from the one laptop per child program. Am Econ J Appl Econ. 2017;9:295–320.
8 Ra CK, Cho J, Stone MD, De La Cerda J, Goldenson NI, Moroney E, et al. Association of digital media use with subsequent symptoms of attention-deficit/hyperactivity disorder among adolescents. JAMA. 2018;320(3):255–63.
9 Gee JP. What Video Games Have to Teach Us About Learning and Literacy. Palgrave Macmillan. 2017.
10 Anastasiadis T, Lampropoulos G, Siakas K. Digital game-based learning and serious games in education. IJASRE. 2018 [cited 2025 Jan 6];4(12):139–44. Available from: https://ijasre.net/index.php/ijasre/article/view/814
11 Bai S, Hew K, Huang B. Does gamification improve student learning outcome? Evidence from a meta-analysis and synthesis of qualitative data in educational contexts. Educ Res Rev. 2020;30:100322.
12 Prensky M. From Digital Natives to Digital Wisdom: Hopeful Essays for 21st Century Learning. Corwin Press. 2012.
13 Swing EL, Gentile DA, Anderson CA, Walsh DA. Television and video game exposure and the development of attention problems. Pediatrics. 2010;126(2):214–21.
14 Cheng KH, Tsai CC. A case study of immersive virtual field trips in STEM education: Students' learning outcomes and reflections. Comput Educ. 2020;145:103740.
15 Li C, Lalani F, Barajas JM. The impact of remote learning on children's social development: Findings from a longitudinal study. Child Dev Perspect. 2021;15(2):79–85.
16 Jiahong Su, Yuchun Zhong, Artificial Intelligence (AI) in early childhood education: Curriculum design and future directions. Comput Educ Artif Intell. 2022;3:100072. https://doi.org/10.1016/j.caeai.2022.100072. ISSN 2666-920X.
17 Yang W. Artificial Intelligence education for young children: Why, what, and how in curriculum design and implementation. Comput Educ Artif Intell. 2022;3:100061. https://doi.org/10.1016/j.caeai.2022.100061. ISSN 2666-920X.
18 Williams R, Park HW, Oh L, Breazeal C. PopBots: Designing an artificial intelligence curriculum for early childhood education. AAAI. 2019 [cited 2025Jan.6];33(01):9729–36. Available from: https://ojs.aaai.org/index.php/AAAI/article/view/5040
19 Zirar A. Exploring the impact of language models, such as ChatGPT, on student learning and assessment. Rev Educ. 2023;11(3):e3433.
20 Shaffer D, Kipp K. Development Psychology: Childhood and Adolescence. Wadsworth Pub Co. 2009.
21 Casey BJ, Tottenham N, Liston C, Durston S. Imaging the developing brain: What have we learned about cognitive development? Trends Cogn Sci. 2005;9(3):104–10. https://doi.org/10.1016/j.tics.2005.01.011. ISSN 1364-6613.
22 Knickmeyer RC, Gouttard S, Kang C, Evans D, Wilber K, Smith JK, Hamer RM, et al. A structural MRI study of human brain development from birth to 2 years. J Neurosci. 2008;28(47):12176–82.
23 Yamamoto Y, Yamaguchi S. Relationships between ICT implementation at schools and factors related to transformational leadership: A case of primary school in Mongolia. Int J Educ Dev Using Inf Commun Technol. 2019;15:45–61.
24 Aladé F, Lauricella AR, Beaudoin-Ryan L, Wartella E. Measuring with murray: Touchscreen technology and preschoolers' STEM learning. Comput Human Behav. 2016;62:433–41.
25 Mayer RE. Multimedia Learning: Principles and Applications. Cambridge University Press. 2020.
26 Vedechkina M, Borgonovi F. A review of evidence on the role of digital technology in shaping attention and cognitive control in children. Front Psychol. 2021;12:1–22. https://doi.org/10.3389/fpsyg.2021.611155
27 Charan GS, Kalia R, Khurana MS, Narang GS. From screens to sunshine: Rescuing children's outdoor playtime in the digital era. J Indian Assoc Child Adolesc Mental Health. 2024;20(1):11–7.
28 Guo RX. CRI Project Report: The Impact of Technology on Attachment and Social Skills. NYS Child Welfare/Child Protective Services Training Institute. 2017 [cited 2024 Dec 13]. Available from: https://digitalcommons.buffalostate.edu/cwcpstriaininginstitute/11
29 Neumann MM. The use of touch-screen tablets at home and pre-school to foster emergent literacy. J Early Child Lit. 2018;18(3):291–317.
30 Steinkuehler C, Duncan S. Scientific habits of mind in virtual worlds. J Sci Educ Technol. 2008;17(6):530–43.
31 Valkenburg PM, Peter J. Online communication among adolescents: An integrated model of its attraction, opportunities, and risks. J Adolesc Health. 2011;48(2):121–7.
32 Twenge JM, Martin GN, Spitzberg BH. Trends in U.S. Adolescents' media use, 1976–2016: The rise of digital media, the decline of TV, and the (near) demise of print. Psychol Pop Media Cult. 2019;8(4):329–45.
33 Kowalski RM, Giumetti GW, Schroeder AN, Lattanner MR. Bullying in the digital age: A critical review and meta-analysis of cyberbullying research among youth. Psychol Bull. 2014;140(4):1073–137.
34 Chotpitayasunondh V, Douglas KM. How 'phubbing' becomes the norm: The antecedents and consequences of snubbing via smartphone. Comput Human Behav. 2016;63:9–18.
35 Turkle S. Reclaiming Conversation: The Power of Talk in a Digital Age. Penguin Books. 2017.
36 Radesky JS, Kistin CJ, Zuckerman B, Nitzberg K, Gross J, Kaplan-Sanoff M, et al. Patterns of mobile device use by caregivers and children during meals in fast food restaurants. Pediatrics. 2016;133(4):e843–9.
37 Barr R, McClure E, Parlakian R. Infant media exposure and toddler development. Dev Psychol. 2010;46(2):419–31.
38 Cristia A, Seidl A. The hyperarticulation hypothesis of infant-directed speech. J Child Lang. 2014;41(4):913–34.
39 Cheung CHM, Bedford R, Saez de Urabain IR, Karmiloff-Smith A, Smith T. Daily touchscreen use in infants and toddlers is associated with reduced sleep and delayed sleep onset. Sci Rep. 2017;7:46104. https://doi.org/10.1038/srep46104.
40 Madigan S, Browne D, Racine N, Mori C, Tough S. Association between screen time and children's performance on a developmental screening test. JAMA Pediatr. 2019;173(3):244–50.
41 Linebarger DL, Piotrowski JT. TV as a talking picture book: The influence of television on young children's language development. Child Dev. 2010;81(5):1691–705.
42 Radesky JS, Christakis DA. Increased screen time: implications for early childhood development and behavior. Pediatr Clin North Am. 2016;63(5):827–39.
43 Clark W, Logan K, Luckin R, Mee A, Oliver M. Beyond the hype: A broader look at the impact of technology on learning. J Res Technol Educ. 2020;52(3):284–99.

44 Nesi J, Prinstein MJ. Using social media for social comparison and feedback-seeking: Gender and popularity moderate associations with depressive symptoms. J Abnorm Child Psychol. 2015;43(8):1427–38.
45 United Nations. Sustainable Development Goals. [cited 2025, Dec 24]. Available from: https://sdgs.un.org/goals
46 Haleem A, Javaid M, Qadri MA, Suman R. Understanding the role of digital technologies in education: A review. Sustain Oper Comput. 2022;3:275–85.
47 Mohebi L. Theoretical models of integration of interactive learning technologies into teaching: A systematic literature review. Int J Learn Teach Educ Res. 2021;20(12):232–54.
48 UNESCO-UNICEF-World Bank. The State of the Global Education Crisis: A Path to Recovery (A joint UNESCO, UNICEF, and World Bank Report). 2021. https://www.worldbank.org/en/topic/education/publication/the-state-of-the-global-education-crisis-a-path-to-recovery?cq_ck=1638565414093
49 Yeung A, Cheung KW. Learner perceptions versus technology usage: A study of adolescent English learners in Hong Kong secondary schools. Comput Educ. 2019;133:13–26.
50 Islam MS, Grönlund Å. An international literature review of 1:1 computing in schools. J Educ Change. 2016;17:191–222.
51 Contrino MF, Reyes-Millán M, Vázquez-Villegas P, Membrillo-Hernández J. Using an adaptive learning tool to improve student performance and satisfaction in online and face-to-face education for a more personalized approach. Smart Learn Environ. 2024;11:6. https://doi.org/10.1186/s40561-024-00292-y
52 Bandyopadhyay S, Bardhan A, Dey P, Bhattacharyya S. Bridging the Education Divide Using Social Technologies. Springer. 2021.
53 Bozkurt A, Gjelsvik T, Adam T, Asino TI, Atenas J, Bali M, et al. Openness in education as a Praxis: From individual testimonials to collective voices. Open Praxis. 2023;15(2):76–112.
54 Chanda T, Sain Z, Shogbesan Y, Phiri E, Akpan W. Digital literacy in education: Preparing students for the future workforce. Int J Res. 2024;11:327–44. https://doi.org/10.5281/ZENODO.13347718
55 Akram H, Abdelrady A, Al-Adwan A. Teachers' perceptions of technology integration in teaching-learning practices: A systematic review. Front Psychol. 2022;13:920317.
56 Manire E, Kilag OK, Habig M, Satin R, Genovania MR, Tan SJ. A technological approach to early childhood education: unveiling the SEEDS pedagogy. Excellencia Int Multidiscip J Educ (2994–9521). 2023;1(5):333–44.
57 Miller T. Developing numeracy skills using interactive technology in a play-based learning environment. Int J STEM Educ. 2018;5(1):1–11.
58 El-Sabagh HA. Adaptive e-learning environment based on learning styles and its impact on development students' engagement. Int J Educ Technol High Educ. 2021;18:53. https://doi.org/10.1186/s41239-021-00289-4
59 Karam R, Pane J, Griffin BA, Robyn A, Phillips A, Daugherty L. Examining the implementation of technology-based blended algebra I curriculum at scale. Educ Technol Res Dev. 2016;65:399–425.
60 Smith BL, MacGregor JT. What is collaborative learning? In Goodsell AS, Maher MR, Tinto V, Leigh Smith B, MacGregor J, editors. Collaborative Learning: A Sourcebook for Higher Education 1992. https://files.eric.ed.gov/fulltext/ED357705.pdf
61 Magen-Nagar N, Shonfeld M. The impact of an online collaborative learning program on students' attitude towards technology. Interact Learn Environ. 2018;26(5):621–37. https://doi.org/10.1080/10494820.2017.1376336
62 Quadir B, Yang JC, Chen N-S. The effects of interaction types on learning outcomes in a blog-based interactive learning environment. Interact Learn Environ. 2022;30(2):293–306. https://doi.org/10.1080/10494820.2019.1652835
63 Hamari J, Koivisto J, Sarsa H. Does gamification work? A literature review of empirical studies on gamification. Proc Annu Hawaii Int Conf Syst Sci. 2016;1(1):3025–34.
64 Means B, Toyama Y, Murphy R, Baki M. The effectiveness of online and blended learning: A meta-analysis of the empirical literature. Teach Coll Rec. 2013;115(3):1–47.
65 Selwyn N. Technology as a focus of education policy. In The Wiley Handbook of Educational Policy 2018;(pp. 457–77). https://doi.org/10.1002/9781119218456.ch20
66 Hirsh-Pasek K, Zosh JM, Hadani HS, Golinkoff RM, Clark K, Donohue C, et al. A Whole New World: Education Meets the Metaverse. Policy. 2022. p. 1–3.
67 OECD. Shaping Digital Education: Enabling Factors for Quality, Equity and Efficiency. OECD Publishing. 2023. https://doi.org/10.1787/bac4dc9f-en
68 World Telecommunication Development Reports. ITU (International Telecommunication Union). 1998; 2002. Available from: http://www.itu.int/ITU-D/ict/publications/wtdr_02/
69 Afzal A, Khan S, Daud S, Ahmad Z, Butt A. Addressing the digital divide: Access and use of technology in education. JSSR. 2023 [cited 2025 Jan. 1];3(2):883–95. Available from: https://ojs.jssr.org.pk/index.php/jssr/article/view/326
70 Wozney L, Venkatesh V, Abrami PC. Implementing computer technologies: Teachers' perceptions and practices. J Technol Teac Educ. 2006;14(1):173–207.
71 Suchita, Gupta S, Devi S, Pal S, Mahajan R. Exploring effective strategies for integrating technology in teacher education. Eur Chem Bull. 2023;12:746–55. https://doi.org/10.48047/ecb/2023.12.si12.065
72 Digital literacy for children: exploring definitions and frameworks SCOPING PAPER August 2019 UNICEF Office of Global Insight and Policy Fabio Nascimbeni. Universidad Internacional de La Rioja Steven Vosloo, UNICEF.
73 Eden C, Adeniyi I. Harnessing technology integration in education: Strategies for enhancing learning outcomes and equity. World J Adv Eng Technol Sci. 2024;11:1–8. https://doi.org/10.30574/wjaets.2024.11.2.0071
74 Livingstone S, Helsper E. Gradations in digital inclusion: Children, young people and the digital divide. N Media Soc. 2007;9(4):671–96.
75 Rideout V, Katz VS. Opportunity for all? Technology and learning in lower-income families. Joan Ganz Cooney Center. 2016.
76 World Health Organization. Guidelines on physical activity, sedentary behaviour, and sleep for children under 5 years of age. WHO. 2019.