Impact of Technology on Cognitive Development in Elementary Education

Impeding Learning

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Abstract

Although technology has many benefits in the field of education, overuse thereof can have a negative impact on the students in varying ways, particularly in their developmental stages of life. Cognition is a vital aspect of childhood development. Schools that are too reliant on technological apps to teach children are interfering with their growth which may hurt them, further down the road. Considering that the brain is developing rapidly in a child's first few years of life makes it even more important that they are involved in varying social interactions and more hands-on learning with others. When exposed to too many forms of technology, they are less involved with other children. Sleep, which is vital at a young age, is impeded by technological apps and devices that children use. Limiting the enhancement thereof can lead to long-term consequences such as digital dementia. With technology continuing to advance in years to come, more individuals will be negatively impacted in a cognitive manner. Modifying the use of technological devices may keep an individual's body enhanced more cognitively, preventing the negative outcomes of using such, particularly in school.

Keywords: cognitive development, amygdala, executive function, executive skills, synapses, visuo-linguistic, neuroplasticity, digital dementia

The Impact of Technology on Cognitive Development

Impeding Learning

Education has changed tremendously in the history of mankind. Just as fertilization has shown to make trees grow more rapidly, technology has made mankind able to produce more products more quickly. Considering such, the wood obtained from trees that were fertilized showed a less density, making it less valuable (Akello, 2024). Technology, in the same manner, affects the brain, involving less interactions of the neurons which can leave long-term effects on individuals. With the continued usage of technological devices, eventually humans will not be capable of performing very simple tasks due to the damage of their bodies.

Piaget divided cognitive development into two stages—sensorimotor and pre-operational (Gustaud et al., 2023). Results showed that children under 18 months, in the sensorimotor stage, who were exposed to digital media for 2 hours or more per day scored lower in cognitive development compared to those who had less exposure. Children who were exposed to the television were 3.9 times more likely to show slower cognitive development than those with less accessibility.

Cognitive and language development were developed on two different scales. The two theories focused on were Chomsky's nativist theory and Tomasello's usage-based theory. Chomsky believed that people are born with a particular language based on exposure, and Tomasello theorized that language is developed with the environment and social interactions. Chomsky's theory is aside from cognitive functions and does not line up with that of Bruner who theorized that individuals seek and construct their understanding, individually (Surakka et al., 2025).

Considering the theories of Piaget, Vygotsky and Bruner, social interaction and hands-on learning are more engaging and keep more of the brain involved, leading to enhanced neuroplasticity. Studies have shown that when people work together, they learn better than when they do so individually (Shamay-Tsoory, 2022). Social alignment involves movement synchronization, emotional and cognitive order. Social interactions involve reciprocation to and from individuals leading them to adjust to learning. When the brain regions are coupled, as they are in this manner, learning is enhanced. Newer research (Shamay-Tsoory, 2022), based on social interactions has shown that coupling between brains may activate more neural networks. Although individuals may benefit from one another in learning, no technological links were shown. The effects of technology on cognitive development is degrading to the human body.

Definitions of Key Terms

1. *Cognitive development*- early stages of development including perception, memory, attention, reasoning and imagination (Gastaud et al., 2023)
2. *Amygdala*- area in limbic system which enables us to be afraid (Pittman, 2022)
3. *Anterior cingulate cortex*- near the frontal lobe and important in decisions, memory and attention (Alho et al., 2022)
4. *Executive skills*- emotional regulation, cognitive flexibility, planning, attention and working memory (Le et al., 2025)
5. *Synapses*- connections made in brain cells (Eret, 2024)
6. *Visuo-linguistic*- communication using images instead of words
7. *Neuroplasticity*- changes in brain matter in response to changes (Eret, 2024)

8. *Digital dementia*- disease of the digital-age which young generations will be impacted by (Eret, 2024)

Related Literature

For the past several years, particularly throughout the COVID-19 pandemic, people have become more advanced in technology in numerous ways. One area that was impacted tremendously was the field of education. No longer were students sitting in classrooms, working together. Instead, they were homebound, working alone on technological apps involved with teaching. Many studies have been carried out on the results thereof. Although digital technology was seen as beneficial in many ways, many negative connotations have been overlooked.

Importance of Early Cognitive Development

Cognitive stimulation in ways such as reading, drawing and playing are vital to develop fundamental cognitive skills. The early years of a child's life, particularly the first five, are essential for proper development. Synapses developed in the first year of life are over 150% of that of adults (LaMonica, et al., 2024). Since language development is said to end at puberty, it is vital that children are receiving the proper interactions and instruction to build their communication skills for years to come (Rizzo et al., 2025). Sleep, in studies by Zhou et al., 2023) has shown to be vital during early childhood, pertaining to brain development. In order for the children to continue developing in the proper manner, it is essential that they are not deprived of their sleep and other requirements that are vital to development in their early years.

Importance of Technology in Education

Computer-assisted instruction (CAI) was used in place of substitute teachers throughout the COVID-19 pandemic (Timotheou et al., 2023). Throughout that time, digital technologies flourished, allowing students who were homebound to connect with their teachers from a greater distance. The advanced technologies, since then, have continued to grow and thrive. Positive aspects were found regarding students' equity and skills, teachers' professionalism and other

areas related to the schools. CAI was found to benefit the students' learning which resulted in higher accomplishments of the students as well as the teachers. The ICT kept the students' attention well and improved their enthusiasm and communication. When examined, students achieved more with non-digital games than they did with digital games. Positive correlations were seen in digital technology concerning learning other languages. This report showed advances in metacognitive education results.

When technology was brought into the school systems, the Technological Pedagogical Content Knowledge (TPACK) was developed to join technology, pedagogy and content knowledge (Wen et al., 2022). This was expected to help students write better. A study was conducted over the past 30 years on changes in writing pedagogy and technology. One form of literacy, digital literacy, involves a broad range of learning styles. Not only are reading and writing involved but visual and auditory forms, as well. Therefore, to be digitally literate, one would need to understand many technical concepts such as writing and editing online. Overall, technology had a more significant impact on writing quantity than it did on writing quality.

Technological Dependence in Education

Varying technologies throughout childhood have a tremendous influence on cognitive development as well as that of social and emotional (Vedechkina et al., 2021). The long-term usage thereof can have effects on cognitive functions, considering that the brain continues to develop through early adulthood (Alho et al., 2022). Executive functions are developed throughout this timeframe. Alho et al. (2022) used functional magnetic resonance images to study multitasking and video games. When an individual on media multitasks (MM), they are using more than one form of digital media at the time. More multitasking per day was associated with a poorer visual working memory. It also negatively affected the visual long-term memory.

More inattentiveness was also associated with multitasks in media. Visuo-linguistic working memory tasks were negatively impacted. Exposure to such leads to rewiring of the brain. Plasticity occurs from the early years until young adulthood, producing billions of new connections that are vital for “hearing, language, and executive skills” (Vedechkina et al., 2021, p. 2).

Rizzo et al. (2025) studied the effects of digital media between preschoolers and adolescents. The Pew Research Center showed in 2020 that 98% of children between 0-6 years of age have access to electronics with an average use of 1-2 hours per day (Rizzo et al., 2025). When parents are involved, this can be beneficial to fine motor skills and potential literacy. However, when unsupervised, exposure can be linked to language problems, sleep, motor control and behavior. When these factors come into play, children aren’t socially connected, and their learning and feelings are influenced. Although digital devices are beneficial in numerous ways, too much usage thereof or usage with no parental guidance may interfere with the development of children’s brains. Of children aged 3-6, with no supervision, the use of digital tools showed less fine-motor skills and manual coordination (Rizzo et al., 2025). From early childhood to adolescence, neural plasticity and development are essential. Excessive screentime may potentially lead to neuroinflammation in children which can affect their development. Individuals who are of the Millenial and Generation Z eras have a greater risk of dementia after 2060 (Rizzo et al., 2025). More neuroplasticity occurs throughout early childhood. The structure of the brain is susceptible to changes during development.

Cognition is affected by such in a negative manner (Shanmugasundaram et al., 2023). People have become reliant on many of these devices due to benefits such as speed, accessibility and effectiveness. Humans are only capable of paying attention for a certain span of time. Many

of the newer technological advances have caused more distractions to individuals. Too much use on smartphones leads to less control of attention. Attentional overload is a concern today because digital devices exceed the cognitive resources that an individual can hold at one time. Texts, reminders and emails are just a few examples of what is coming through, almost constantly, through digital devices. These disturbances impede people's attention span. One con to multitasking is that it interferes with people's capability of focusing and retaining information. One influence contributing to the digital world is all the prompting, leading to attentional overload. Another is the overwhelming abundance of data that is accessible which may cause people to develop habits. Concentration on work is interfered with due to the frequent reminders by alarms. This distracts workers which makes their productivity slower, causing hindrances to their work. Cognitive tests have shown lower scores for children who used digital devices for over 2 hours per day. Staying on video games for too long interferes with an individual's attention. Extensive use of digital devices is associated with attention deficit hyperactivity disorder (ADHD) symptoms. Reliance on artificial intelligence (AI) interferes with critical thinking.

Digital technology is drawing more attention. It has even been referred to as "an enemy" (Madsen et al., 2023, p.2) of childhood practice. While researchers argue that this hinders children's development, parents believe that digital realms are helping their children. In this study, 22% agreed that children do not need to be skilled in digital technology, while 19% strongly agreed (Madsen et al., 2023).

Clemente-Suarez, V. et al. (2024) explored the relationships between digital devices and cognitive development. Although society is rapidly advancing in the use of digital devices, the impact could be negative towards children's cognitive development. In 2021, studies showed that

children had phones as early as 12.2 years old. These devices affect individuals' "attention, memory, and socio-emotional development," (Clemente-Suarez, V. et al., 2024, p.2) particularly when used excessively. Although digital devices help with neurotransmission, the use may lead to other impairments. The working memory can only store so much data, so too much may cause problems. The fast-flashing screens hinder attention and interfere with deeper cognitive tasks, interfering with the retention of memories and attaining education. "Cognitive overload" (Clemente-Suarez, V. et al., 2024, p.5) is very damaging in the early stages of development.

Essential Sleep

Sleep is vital to cognitive development, and functional development is essential during sleep (Mason et al., 2021). At nighttime, sleep has even shown to be beneficial to young children through adulthood (Cai et al., 2023). When the sleep quality was poor, it was linked to worse cognition. Sleep is important for memory. Lack thereof disturbs the prefrontal cortex which is where executive functioning and alertness lie. Better sleep, in infants, has even shown to be important in the development of language. The most vital months of development shown in this study were in the first 24 months of a child's life, affecting their neurological development. Better sleep, in infants, has even shown to be important in the development of language. The most vital months of development shown in this study were in the first 24 months of a child's life, affecting their neurological development.

In infants, napping benefits the memory in those as young as three months (Mason et al., 2021). In children over the age of five, sleep was shown helpful for declarative memory. In those between the ages of 7 and 12, word recognition improved after sleep. For children of the ages 8-11, sleep showed augmented hippocampal activity. In early childhood, sleep was shown to be important for emotion processing. In a study of individuals ranging from 2 to 26 years, slow-

wave activity (SWA) “predicted cognitive performance and gray matter maturation” (Mason et al., 2021, pp. 1-2). The hippocampus has shown to have varied volumes between children ages of four and six in their napping patterns (Mason et al., 2021).

According to the American Academy of Pediatrics and the Brazilian Society of Pediatrics, children under the age of 2 should not be exposed to screens (Gustaud et al., 2023). Between 2 and 5 years of age, the screen time should be limited to 1 hour per day, and after 5 years of age, the maximum should be 2 hours per day. In the first 2 years, children’s brains are making connections, developing in language, motor skills and cognition.

Digital devices also disrupt sleep. The blue lights of devices interfere with melatonin production which is vital for sleep (Shanmugasundaram et al., 2023). Cognitive development that is important throughout sleep is interfered with through media (Rizzo et al., p. 10). Melatonin is delayed which interferes with the amount and quality of sleep. Using more than one device at one time is called media multitasking (Shanmugasundaram et al., 2023). This has shown reduced gray matter density in the area of the brain associated with cognitive and emotional regulation, the anterior cingulate cortex. AI Chatbots are used in cognitive-behavioral-therapy but have shown to negatively affect the amygdala and prefrontal cortex. A study using MRIs showed that sleep duration was related to bilateral hippocampal gray matter volume (Zhou et al., 2023, p. 5362). Aljo et al. (2022) referred to a study that had shown less gray matter in the anterior cingulate cortex. The results showed that media multitasking (MM) negatively affects young people’s frontal lobes which continue to develop further through early adulthood.

Communication and Language

Neuroplasticity is occurring at birth and is essential in the early years, developing essential skills such as language development (Vedechkina, 2021). There are many aspects of

language development (Surakka, et al., 2025). This study focused on language development and cognition at the ages of 2 years, 3.5 years, and 5 years of age. children at two years old have a distinctive language ability. The 3.5 year olds were able to name and show morphological skills (Surakka et al., 2025). The results showed no association between the cognitive or language development of the two- year- old or the three-year, six-month little one. Early and later language was shown a great deal. Early development was very important for cognition, but there were factors missing in the early childhood years. Early language development was shown to be a strong predictor for later language in life than cognitive skills.

Screen time interferes with language development and cognition (Yang et al., 2024). High-quality programs showed differently. Screentime and cognitive development were both shown to affect families' socioeconomic factors. The screen time takes away from other times that could help build the children cognitively. The results showed that watching television during family meals negatively affected the children's expressive language at 2 years old and the cognitive development at 3.5 years old (Yang et al., 2024). Language development is said to end close to puberty (Rizzo et al., 2025). Exposure to digital devices could interfere with this development.

Communication on digital devices can lead to people believing that they are able to show and perceive emotions because they are perceived inappropriately (Shanmugasundaram et al., 2023). Relying too heavily on technology to resolve issues for people is not good for people because the brain cannot process but so much information at a time.

Varying Countries and Cultures

The studies were conducted in varying countries—the United States of America, Australia, Canada, Norway, Sweden, the United Kingdom, Italy, Finland, Germany, Poland,

South Korea and Turkey. Children, aged 2-7, were involved, excluding those who had varying impairments such as autism and attention hyperactivity disorder. Cognitive as well as social and emotional outcomes have shown to be worse in varying countries with low socio-economic status (Johnstone et al., 2022). Although such is true, low- and middle-income countries (LMICs) have children not developing properly due to malnutrition and lack of social interaction which interferes with cognitive development, as well (LaMonica et al., 2024).

The Council of the European Union looked at the top eight competences of education, and digital competence was one of the eight found. Perceptions were gathered from varying countries through surveys (Madsen et al., 2023). In Norway, digital technology is mandatory in all ECE areas, but in Slovenia, the ECE do not even encompass digital competencies. In Portugal and England, technology is blended into the curriculum. Poland pushes for the teachers to learn beforehand. In Jordan, digital technology is very partial in preschool. Communication problems occurred in Poland. Varying nations had different norms. The results showed a broad band of scores from lowest to highest-scoring countries. The countries that scored the lowest on expected use seemed to be the ones that agreed least with having more digital tools in ECE.

Digital Dementia

Neuroscientists are studying digital dementia and dying neurons as a result of digital media, particularly for young children (Eret, 2024). With the brain constantly making new connections, synapses increase. The myelin sheath on nerve fibers grows and are more visible on scans such as MRIs. Eret (2024) noted that when brain cells multiply, the hippocampus increases in volume. That causes a grey matter in the hippocampus which is good. However, the stress of digital media is causing more death of brain cells. Since Alzheiemer's disease starts in the hippocampus and there is death of brain cells, that is why the digital age is making more

young people susceptible to digital dementia. Eret (2024) showed in one study that physical activity is important in dealing with emotions.

Digital dementia is associated with the excessive use of digital devices. This can cause memory problems and troubles with communication (Shanmugasundaram et al., 2023). Relying too heavily on digital devices can impair recollection and can change the brain's functions. Over time, retention is impacted negatively through digital devices.

Learning Theory Association

The theory of cognitive development was brought about by Jean Piaget (Clemente-Saurez et al., 2024). Piaget stated that showing that hands-on learning is vital during a child's development. Too much screentime interferes with the development of language. Lev Vygtotsky stated in his socio-cultural development that social interactions are very important in a child's development. When children are using digital devices, they do not get to work with others, physically, which hurts their social development. Neurological development is vital in early childhood.

Cognitive and language development were studied on two different theories. The two theories focused on were of Chomsky's nativist theory and Tomasello's usage-based theory (Surakka et al., 2025). Chomsky believed that people are born with a particular language based on exposure, and Tomasello theorized that language is developed with the environment and social interactions. Chomsky's theory is aside from cognitive functions. Tomasello's theories seem to align more-so with those of Jerome Bruner. Bruner looked at how children epitomize knowledge.

Gaps in Research

The area of technological devices affecting cognitive development has shown little research. Most research has been associated with the positive aspects of 5G and a fast and easy way to accomplish tasks. Further studies could be conducted on enhancing the varying regions of the brain instead of completing everything so quickly.

Biblical Worldview

The Lord made mankind with a purpose. That purpose is to work to honor Him. Just as He asked Adam and Eve, in the garden, to work, He expects all of His people to work. Everyone was created with different callings, each blessed with varying gifts. Colossians 3:23 states, “And whatsoever ye do, do it heartily, as to the Lord, and not unto men” (KJV). People are not supposed to expect recognition from mankind. As Paul wrote in Corinthians, God created human’s bodies as temples of the Holy Ghost. He calls everyone to work, and everyone’s work should be done for Him. Solomon said in Proverbs 20:4, “The sluggard will not plow by the reason of the cold; therefore he shall beg in harvest, and have nothing” (KJV). Since everyone’s bodies are temples of the Holy Spirit, harming the body by not working and keeping the brain active is not what God expects of His people. People should praise God that they are able to work and not complain about working.

Conclusion

Individuals may have achieved a lot since the creation of mankind, but when they are harming their bodies through dependence on technology, they are not only hurting themselves but others. In order to keep the brain functioning properly, it is vital that schools and homes continue to learn through social interaction and not through technology. Just as the trees have shown low density due to fertilization by mankind, individuals’ brains are showing less

neuroplasticity through digital technology. As Psalm 182:2 says, “Ye will eat the fruit of your labor” (KJV), people will enjoy the outcomes of their hard work.

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