

NEUROSCIENCE, ATTENTIONAL CONNECTOME, AND INTELLIGENT TECHNOLOGIES IN THE EDUCATIONAL CONTEXT

NEUROCIÊNCIA, CONECTOMA ATENCIONAL E TECNOLOGIAS INTELIGENTES NO CONTEXTO EDUCACIONAL

NEUROCIENCIA, CONECTOMA ATENCIONAL Y TECNOLOGÍAS INTELIGENTES EN EL CONTEXTO EDUCATIVO

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ABSTRACT: Cognitive neuroscience and artificial intelligence form a rapidly expanding convergence for understanding neural and mental mechanisms and developing systems applicable to education. Neuroscience studies the brain as the core of learning, while technologies develop computational codes and simulate human cognitive functions. Attention is the central axis for other cognitions for knowledge acquisition and learning. Objective: to describe the fundamentals of attentional cognitive neuroscience and its convergence with technologies in the educational context. Methods: This is a scoping review with a three-year time frame, conducted in the SciELO, NCBI/PubMed®, and Science Direct databases, guided by the PCC (Population, Context, Concept) mnemonic strategy for formulating the guiding question and by the PRISMA-ScR checklist. Results: Twenty-eight articles met the research criteria. Convergences and advances in educational technologies were observed, with effects on attentional cognition that optimize concentration and personalization of learning. Considerations: The synergy between neuroscience and technologies drives educational transformations, considering the potential of the brain as the organ of learning.

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Keywords: Connectome. Attention. Learning. Digital technologies. artificial intelligence.

RESUMO: A neurociência cognitiva e a inteligência artificial formam uma convergência em rápida expansão, para compressão do mecanismo neural, mental e desenvolvimento de sistemas aplicáveis à educação. A neurociência estuda o cérebro como núcleo da aprendizagem enquanto as tecnologias desenvolvem códigos computacionais e simulam funções cognitivas humanas. A atenção constitui o eixo central às demais cognições para aquisição do conhecimento e aprendizagem. Objetivo: descrever os fundamentos da neurociência cognitiva atencional e suas convergências com as tecnologias no contexto educacional. Métodos: trata-se de uma revisão de escopo com recorte temporal de três anos, realizadas nas bases da SciELO, NCBI/PubMed® e Science Direct, orientada pela estratégia mnemônica PCC (População, Contexto, Conceito) para formulação da questão norteadora e pelo checklist PRISMA-ScR. Resultados: foram vinte e oito artigos que atenderam aos critérios da pesquisa. Verificam-se convergências e avanços das tecnologias na educação, com efeitos da cognição atencional que otimizam a concentração e personalização do aprendizado. Considerações: a sinergia entre neurociência e tecnologias impulsionam transformações educacionais, considerando o potencial do órgão da aprendizagem que é o cérebro.

Palavras-chave: Conectoma. Atenção. Aprendizagem. Tecnologias digitais. Inteligência artificial.

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RESUMEN: La neurociencia cognitiva y la inteligencia artificial convergen rápidamente hacia la comprensión de los mecanismos neuronales y mentales, así como hacia el desarrollo de sistemas aplicables a la educación. La neurociencia estudia el cerebro como núcleo del aprendizaje, mientras que las tecnologías desarrollan códigos computacionales y simulan las funciones cognitivas humanas. La atención es fundamental para la adquisición y el aprendizaje de conocimientos. **Objetivo:** Describir los fundamentos de la neurociencia cognitiva atencional y sus convergencias con las tecnologías en el contexto educativo. **Métodos:** Se trata de una revisión exploratoria de tres años, realizada en las bases de datos SciELO, NCBI/PubMed® y Science Direct, guiada por la estrategia mnemotécnica PCC (Población, Contexto, Concepto) para la formulación de la pregunta guía y por la lista de verificación PRISMA-ScR. **Resultados:** Veintiocho artículos cumplieron los criterios de investigación. Se observaron convergencias y avances en las tecnologías educativas, con efectos de la cognición atencional que optimizan la concentración y personalizan el aprendizaje. **Consideraciones:** La sinergia entre la neurociencia y las tecnologías impulsa las transformaciones educativas, considerando el potencial del cerebro como órgano del aprendizaje.

Palabras clave: Conectoma. Atención. Aprendizaje. Tecnologías digitales. Inteligencia artificial.

1 INTRODUCTION

In the educational context, artificial intelligence (AI) and digital technologies (DT) apply computer systems that assist teaching and learning, personalizing classroom experiences. Adaptive platforms and virtual tutors are used to contribute to academic performance and pedagogical optimization. They integrate strategies linked to neurocognitive and technological functions to enhance teaching and learning activities. One example is the Khan Academy platform, which uses algorithms to analyze the pace, accuracy of tasks, and student responses, adapting activities to reinforce cognitive functions such as attention and memory (Dousset et al., 2025; Hernández-Chávez et al., 2025).

Intelligent technologies (IT) are AI-assisted and digital systems that replicate human intelligence through sensors, devices, connectivity, and automation of these systems that learn from data, optimizing tasks and interacting adaptively with users and the environment. In the contemporary context, marked by rapid transformations, education does not remain static but faces challenges in the face of continuous change. It is in this scenario of personalized teaching that the so-called Education 4.0 is consolidated, resulting from disruptive technological innovations in light of the Fourth Industrial Revolution (Zegarra et al., 2025; Matias et al., 2025).

Artificial intelligence (AI) consists of technologies that enable computer systems to perform a variety of functions similar to human abilities, such as the ability to see, understand, develop dialogues, translate spoken and written language, analyze data and images, recommend decisions, among other tasks. AI is often used to describe the automation of complex tasks, performed digitally, which changes the approach to educational practices and is becoming

essential for time management and personalization of teaching, according to Chen and Yadollahpour (2024) and Zegarra et al. (2025).

Since the 1940s, digital computing has been programmed to perform complex tasks, such as discovering proofs for mathematical theorems and playing chess, as vividly portrayed in the experience of the first victory of a computer that played against Garry Kasparov with great proficiency. Despite advances in processing speed and computational memory capacity, there are still no programs that match the flexibility cognitive flexibility in a broad domain (Badrulhisham et al., 2024; Abishev et al., 2025).

Although AI systems achieve performance comparable to human experts in specific tasks and decision-making, they still face limitations in textual comprehension and adaptation. Nevertheless, such technologies are advancing in multiple areas, including education, health, and medical diagnosis. They use search engines, voice recognition, digital platforms, task automation, and others. AI expresses a computational ability to learn and improve in a manner analogous to human cognition, and this has driven the study of connectomes, mainly through artificial neural networks (ANN) according to Shekouh et al. (2024) and Horien et al. (2023).

In the educational environment, AI has contributed significantly with digital technologies and other intelligent systems that aid teaching, personalizing experiences and adapting content to the individual needs of students. Currently, several tools promote greater engagement, facilitate real-time analysis of student performance, facilitate formative assessment, stimulate attentional cognition, and create interactive environments with more dynamic activities (Kamalov et al., 2023; Hernández-Chávez et al., 2025; Abishev et al., 2025).

In this scenario, cognitive neuroscience (CN) contributes to these advances by studying brain functions such as attention, memory, emotions, and decision-making, mapping neural connectomes with AI-assisted technologies. Functional magnetic resonance imaging (fMRI), for example, maps cognitive processes related to learning based on neural data, elucidating mental processes such as attentional cognition. Attention is a selective mechanism that organizes information in neural circuits to enhance mental, behavioral, and learning processes (Xia et al., 2024; Martín-Signes et al., 2024).

The convergence of AI and CN amplifies mutual advances, integrating knowledge about how the brain works during learning, linked to the development of Deep Learning (DL) computational algorithms. AI enhances the analysis of connectomes and large volumes of data in brain-computer interfaces, making it possible to identify complex mechanisms of the attentional connectome. Cognitive attention is essential for focusing on relevant stimuli and

can be simulated and stimulated by educational technologies, promoting executive functions and learning effectiveness (Matias et al., 2025; Yang et al., 2025). Thus, the objective is to describe the fundamentals of attentional cognitive neuroscience and its convergences with technologies in the educational context.

2 METHODS

This is a scoping review that used the Joanna Briggs Institute (JBI) methodology and the Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews-PRISMA-ScR recommendations, according to Peter et al. (2020). This type of research makes it possible to identify gaps and map topics of interest through systematic analysis.

The guiding question of the research was developed using the PCC mnemonic strategy, based on the following elements: P-Population, C-Concept, and C-Context. NC was considered to be focused on attention as a learning process, thus delimiting the elements (P). Neuroscientific processes of cognition assisted by intelligent technologies (AI and TD) were defined as the concept (C). The integration of AI, its subareas applicable to the mental processes of attention in learning, denoting the context element (C). This structure generated the guiding question of the present study: What is the interface scenario of cognitive neuroscience with an emphasis on attentional cognition and its convergences with intelligent technologies in the context of educational learning?

The following Health Sciences Descriptors (DeCS) were used: “cognitive neuroscience,” “attention,” “artificial intelligence,” “digital technologies,” and “learning.” In the English version: learning; artificial intelligence; attention, cognitive neuroscience. The Boolean operators “OR” and “AND” were used in searches of the SciELO, PubMed®, and Science Direct databases to obtain publications from 2023 to 2025. State of the Art through Systematic Review (StArt) was used to minimize excesses and duplication in searches, and the Zotero app was used to organize references.

Eligibility criteria: primary and secondary articles, meta-analyses, retrospective in silico and prospective research articles on AI-applicable or AI-assisted technologies were considered eligible, focusing on the main object of this study. Exclusion criteria were articles that did not address the study question, literature reviews, theses, dissertations, duplicate studies, articles that were not in the public domain, and gray literature.

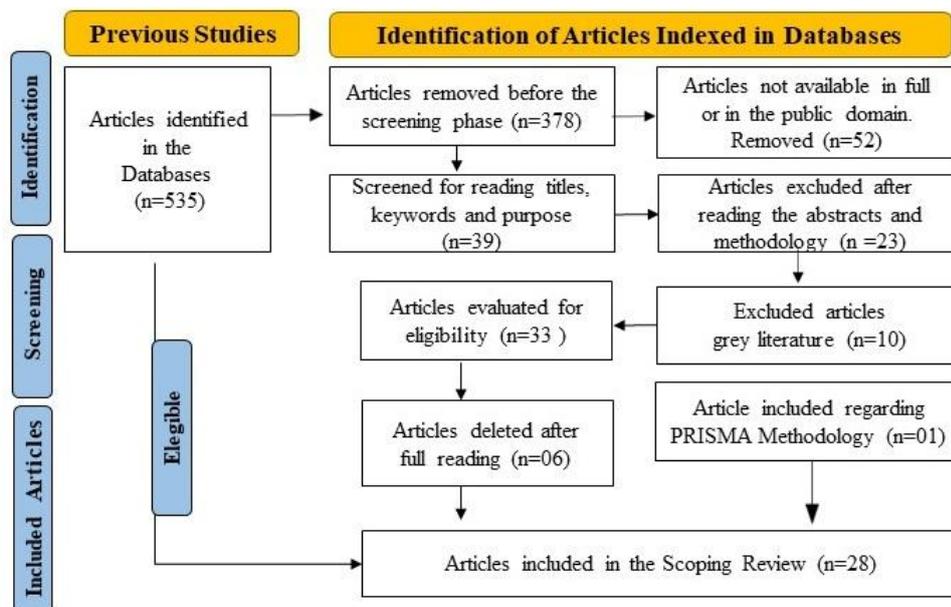
Searches for articles in indexed databases were conducted in August and September 2025. In the first stage, titles and abstracts were read and recognized, followed by a new selection, reading of the articles in full, and filtering according to the PRISMA flowchart . The selected articles were read, analyzed, and synthesized by the authors of this study in a collaborative manner.

The methodological quality of the studies collected was not an eligible criterion for evaluation or application of an evaluation protocol, as it is optional in a scoping review. The type of study does not require submission to the Research Ethics Committee (REB) as it was conducted using data in the public domain.

3 RESULTS

A total of 535 articles were initially identified in the databases, and approximately 378 were removed in the first screening based on the research criteria and question, or due to duplication. Verification of disparate titles and references eliminated 39 articles. In the subsequent analysis, 23 articles were removed after verification of abstracts and methodologies. The application of the pre-established criteria and filters is described in the flowchart. 28 articles were eligible to compose the sample for this study, as shown in Figure 1.

Figure 1. Flowchart adapted from PRISMA-ScR describing the search process for articles used, published from 2023 to 2025.



Source: Flowchart prepared by the authors.

To facilitate understanding of the different mechanisms of attention, Table 1 summarizes the main types of attentional cognition, their fundamental characteristics, and practical examples, shedding light on the mechanisms and manifestations of the attentional process.

Table 1: Typology, characteristics, and examples of attentional cognition.

Type of Attention	Definition	Characteristics	Practical Example
Selective	Focusing on a specific stimulus.	Intense concentration; filtering of distractions.	Studying in a library while ignoring surrounding conversations.
Alert / Phasic	Concentration dependent on environmental changes.	Rapid and transient adjustment of alertness; focus on a specific event.	Interrupting a task upon hearing the sound of thunder.
Sustained	Maintaining focus for a prolonged period.	Consistency; resistance to mental fatigue.	Staying focused on an activity for hours without distraction.
Alternating	Shifting focus between different stimuli.	Cognitive flexibility; rapid switching of focus.	Listening to the teacher, writing, and alternating text reading.
Divided	Attention to multiple tasks simultaneously.	Mental multitasking; parallel attention.	Driving while listening to GPS instructions and talking to a passenger.

Source: prepared by the authors

The interface between aspects of attentional cognition and the use of digital technologies, their benefits, and potential risks are summarized in (Table 2). Examples of influencing factors include duration, type of media, time of day, and number of devices. Moderate and guided use can support learning, while excessive screen time and lack of mediation by parents and teachers can be detrimental.

Table 2: Mutual influence of digital technologies and attentional cognition, their effects, and regulation.

Aspect	Description	Benefits	Risks / Impairments
Attentional Cognition	Ability to select, maintain, and shift focus among digital stimuli.	Divided stimulation and increased mental agility.	Reduced sustained attention and increased distractibility.
Digital Technologies	Interactive content and multiple stimuli competing for attention.	Rapid access to information, interactivity, engagement.	Cognitive overload, distraction, and reduced concentration.
Educational Regulation	Conscious use of technologies by schools and families.	Development of healthy habits and reinforcement of cognitive skills.	Lack of limits and excessive use impair attention.

Source: prepared by the authors

The analytical basis on neuroeducation, adaptive instructional design, and digital interventions in cognitive attention contexts in learning, related to the object of this study, are summarized (Table 3).

Table 3: Smart technologies in the educational context and attentional cognition.

Category	Educational Applications	Contributions to Attentional Cognition	Technologies Employed
Tutoring Systems	Adaptive and personalized platforms.	Focus on relevant information and reduced cognitive overload.	Artificial Intelligence (AI).
Engagement Analysis	Monitoring attentional behavior through interaction.	Identification of attentional lapses and pedagogical adjustment.	AI and learning analytics systems.
Gamification and Adaptive Feedback	Educational games with personalized reinforcement.	Sustained focus through gradual challenges and motivational stimuli.	Digital technologies and AI.
Immersive Environments	Immersive learning activities.	Intensification of selective attention through integrated sensory stimuli.	Virtual Reality (VR) and Augmented Reality (AR).
Educational Chatbots	Interactive conversational virtual assistants.	Maintenance of attention through responsive and personalized interactions.	AI and Natural Language Processing (NLP).
Smart Notifications	Alerts based on attentional patterns.	Redirection of attention to priority tasks and time management.	AI and predictive systems.
Attentional Cognitive Tracking	EEG and sensors integrated into platforms.	Monitoring attentional focus in real time and enabling pedagogical adjustments.	AI, neurofeedback technologies, eye-

Source: prepared by the authors

RT: Real Time; EEG: Electroencephalogram; AI: Artificial Intelligence; NLP: Natural Language Processing

4 DISCUSSION

Given the preponderance of attention as the central axis of learning and the growing role of intelligent technologies, this discussion is structured around three axes: basic aspects of the neurobiology of attentional cognition and the relevant brain connectome, basic concepts and applications of intelligent technologies (IT) to those assisted by artificial intelligence and digital technologies, and their effects on attentional cognition in the educational context.

4.1 NEUROBIOLOGY OF ATTENTIONAL COGNITION AND CONNECTOME

Faced with the multiple demands of contemporary educational action, the articulation between technological skills and knowledge about the neurobiology of the brain and learning,

especially the mechanisms of the attention connectome, emerges as a central axis of cognitive neuroscience (Zegarra et al., 2025; Horien et al., 2023). This convergence suggests a transformative potential in the design of educational processes (Dousset et al., 2025), aiming to improve understanding of brain functioning and learning effectiveness (Chen and Yadollahpour 2024; King et al., 2023).

Cognitive neuroscience is an interdisciplinary field that integrates neuroscience, psychology, and cognitive science with the aim of understanding the brain activity that underpins mental processes such as perception, memory, decision-making, and problem-solving. To this end, it employs methods and techniques such as neuroimaging, behavioral experiments, and computational modeling to investigate the neural mechanisms underlying cognitive functions (King et al., 2023; Xia et al., 2024).

For neuroscience, the attentional connectome represents the processes that allow individuals to selectively focus on specific stimuli by recruiting attention and concentration. This cognitive function is essential for navigating complex environments and performing focused tasks effectively. This mechanism involves a diverse network of connections in the brain connectome, mainly for the coordinated action of the dorsal attention network (DAN) and the ventral attention network (VAN), responsible for the integrated modulation of attentional processes (Krauzlis et al., 2023; Horowitz-Kraus et al., 2025).

The attentional connectome is an architecture of structural and functional connectivity of the neural networks involved in attention processing (primary DAN and VAN). Attention mechanisms (voluntary and involuntary) are essential for processing focus, concentration, and learning. Understanding the neural circuits that prioritize stimuli is vital for neurolearning and also serves in the diagnosis and treatment of attention disorders. Correlated brain regions—prefrontal, bilateral parietal, and dorsolateral cortices—are involved in changes in attention (Horien et al., 2023; Martín-Signes et al., 2024).

In terms of control mechanisms, the types of attention are: selective, exogenous (external), and endogenous (internal), manifesting as involuntary (reactive) or voluntary (intentional). This duality results in two central processes: "top-down" (goal-directed) and "bottom-up" (reactive to stimuli). The prefrontal cortex functions as the cognitive control center, regulating focus and modulating visual activity, which is essential for executive functions, planning, and working memory. These functions coordinate thoughts, emotions, and actions and are involved in learning (Xia et al., 2024; King et al., 2023; Qu et al., 2024).

Attentional control is maintained by the interaction of neural networks (DAN and VAN), forming an adaptive system. Changes in the connectome of attention can cause cognitive disorders, such as difficulty in sustained attention, and can culminate in Attention Deficit Hyperactivity Disorder (ADHD). Such conditions lead to difficulties in academic, professional, and social performance. Therefore, the use of predictive models (AI/DL) based on connectome data can aid in the diagnosis and understanding of these conditions, enabling personalized clinical and educational interventions (Horien et al., 2023; Horowitz-Kraus et al., 2025).

Attention is a multidimensional cognitive function, essential for the individual's interaction with the environment, allowing for the selection, processing, and ability to respond to relevant stimuli. The Neuroscience of the Attentional Connectome (NAC) explores the complex functions of the brain in processing attention, modulating and triggering the influence of internal and external factors. Highlighting neural plasticity, important for the pedagogical context, demonstrating that the student's brain can adapt and change according to experiences and stimuli (Li et al., 2025).

The study on brain connectivity, investigated by initiatives of the Human Connectome Project, maps the neural pathways responsible for different brain communications. Their efficiency and speed are modulated by myelination and axon diameter, which are determinants of attention performance. Neurotransmitters such as norepinephrine and dopamine exert central regulation of attention and focus, and changes in this neurochemical system are associated with cognitive and learning impairments (M. (Weigard et al., 2024; Martín-Signes et al., 2024).

Other authors explain that attention stimuli are encoded by the brain through three neuroanatomical systems. The Alert System or Reticular Activating System (RAS) in the frontal areas, limbic system, thalamus, and basal ganglia collects information and is primarily responsible for the abilities of arousal and sustained attention. The Posterior Attention System (PAS), which guides, controls, and uses focused and selective attention skills to encode visual stimuli through the areas of the superior colliculus, posterior parietal cortex, and lateral nucleus of the thalamus. And the Anterior Attention System (AAS), an executive system that uses Selective Attention, related to the dorsolateral prefrontal cortex, orbitofrontal cortex, anterior cingulate cortex, supplementary motor area, and striatum (Krauzlis et al., 2023; Gkintoni et al., 2025).

Thus, sustained attention is critical for focusing on a particular stimulus for an extended period, even in the face of distractions. This is because learning involves the formation and modification of synapses (neuroplasticity), and attention directs relevant stimuli. Identifying modifiable regulatory mechanisms, such as attentional control, executive functions, and affective-emotional flexibility, is central to effective educational interventions (Li et al., 2025; Schwarz et al., 2025).

Therefore, the DAN network is associated with supporting goal-directed attention tasks, while the VAN is activated by unexpected stimuli. The modulation of attentional focus depends on the interaction of these networks studied by neuroscience. Recent interdisciplinary studies have used AI-assisted neuroscientific techniques to map and analyze these networks, identifying individual differences in attention capacity based on connectivity, deepening the understanding of the mechanisms underlying this connectome (King et al., 2023; Schwarz et al., 2025).

4.2 INTELLIGENT TECHNOLOGIES AND THE COGNITIVE APPROACH

AI-assisted intelligent technologies represent an important advance in the ability to simulate human behavior, in some cases even surpassing human performance in specific tasks (Abishev et al., 2025). Artificial intelligence, particularly Deep Learning (DL) and Artificial Neural Networks (ANN), draws inspiration from the structure and function of the human brain to develop transformational algorithms to enhance learning (Shekouh et al., 2024).

The integration between neurobiology and cognition of attention uses imaging technology to identify brain interconnections, relating cognitive operations to neural networks involving specific attention functions. Resting magnetic resonance imaging during cognitive tasks allows tracking the development of attentional circuitry from childhood. Through optogenetics technology, for example, connections between attention and memory have been identified and mapped in animal models. This demonstrates the importance of attentional networks, which enable personalization by controlling populations of attention and memory neurons that operate together in human learning processing (Schwarz et al., 2025; Li et al., 2025).

The convergence between AI and NC is bidirectional. CN provides knowledge about the physiology of learning, which is useful for designing more efficient and robust AI algorithms, as occurs in the area of reinforcement learning. In turn, AI, with its ability to process large volumes of data (Big Data) and identify complex patterns that traditional statistics do not detect, accelerates neuroscientific research. It enables the improvement of

Machine Learning (ML) techniques, guiding the design of algorithms inspired by learning behavior, making AI more adaptive and effective (Matias et al., 2025; Yang et al., 2025).

The study of selective attentional cognition has been further enhanced by predictive AI modeling (MPIA) based on connectomes and ML techniques (a subarea of AI) to analyze network connectivity. These technologies investigate the complex process of neural circuitry and neurotransmitters using imaging techniques such as functional magnetic resonance imaging (fMRI) and positron emission tomography (PET). Key cortical regions of attentional cognition include the frontal eye field, superior parietal lobe, and interparietal sulcus, which are activated in tasks requiring spatial attention (Hernández-Chávez et al., 2025; Qu et al., 2024).

This study analyzed how evidence accumulation efficiency (EAE) relates to the adaptation of cognitive control networks under different mental demands in 5,198 participants of the Human Connectome Project (HCP). They applied the n-back test with fMRI, the results of which indicated that individuals with higher EEA exhibit greater flexibility in task-positive networks, which are more activated in frontoparietal regions and the DAN network. The adaptability of these networks is a central mechanism of cognitive efficiency; they function as a control of cognitive intensity and are measurable by fMRI technologies. The greater the cognitive demand during learning, the greater the neural recruitment of attentional networks (Weigard et al., 2024).

The benefits are evident in the transformations in education driven by technologies that expand pedagogical resources, promote personalization, interactivity, and improved academic performance (Table 3). AI adapts to educational contexts and supports managers, teachers, and students, arousing growing scientific and social interest (Kamalov et al., 2023). For Yang et al. (2025), this technological immersion redefines educational paradigms by structuring smart education around techno-pedagogical pillars, environments, learning, and students immersed in integrated and cohesive technological ecosystems to support the teaching-learning process in a holistic and more effective way (Badrulhisham et al., 2024; Matias et al., 2025).

AI enables computer systems to learn from experience and perform tasks associated with human intelligence (learning, reasoning, language). Generative AI is a type of AI focused on creating original content (text, images, videos, audio, code) based on a natural language command, using DL algorithms to automate creative tasks, for example. The convergence between NC and IT has shown high potential for compressing cognitive processes and developing intelligent educational systems, promoting attention, concentration, focus, and

personalization, as well as accelerating content assimilation, academic success, and expanding educational opportunities (Chen and Yadollahpous et al., 2024; Badrulhisham et al., 2024; Yang et al 2025).

It is essential to distinguish between technologies, as digital technologies are based on binary coding to process information and are widely applied in the fields of education, health, and communication. They have an impact on instructional design in cognitive attention interventions such as smartphones, social networks, and educational applications (Table 3). These are intelligent technologies assisted by AI, ML, and DP, enabling learning, adaptation, and autonomous or semi-autonomous decision-making (virtual assistants, autonomous cars). Generative AI automates tasks, analyzes large volumes of data, and identifies patterns, all of which expand educational possibilities (Al-Abyadh et al., 2024; Zegarra et al., 2025; Badrulhisham et al., 2024).

IAGen has achieved prominence in education for its multiple contributions, performing repetitive tasks (translations, transcriptions), optimizing time, speeding up processes, and increasing productivity in educational practice. It assists in data analysis and categorization, identifying relevant patterns to guide attention and focus strategies in learning conditions. It creates promising convergences, while neuroscience underpins and drives models for AI, which in turn breaks new ground with disruptive tools for brain research and educational possibilities (Abishev et al., 2025; Zegarra et al., 2025; Matias et al., 2025).

4.3 IT INTERFACE IN THE EDUCATIONAL CONTEXT

The convergence of IT in education presents itself as a digital portal (applications, platforms, and devices) that connects students, teachers, and content, creating interactive, personalized, and collaborative learning experiences through tools such as Learning Management System (LMS) platforms like Google Classroom, videoconferencing (Zoom), gamified applications (Kahoot), interactive whiteboards, and others. This increases engagement, flexibility, and personalization of teaching and promotes active learning beyond traditional methods (Shwlani et al., 2024; Ansari et al., 2025).

AI and DT in the educational environment have also contributed to the personalization of teaching and the adaptation of content to the individual needs of students. Digital tools promote greater engagement, facilitate real-time performance analysis, and create interactive environments that stimulate attentional cognition in learning. This stimulation by IT goes beyond personalization, contributing to reducing overload through the use of adaptive

platforms, as shown in Table 3, which adjust difficulties and the pace of content development to optimize concentration and focus on essential information (Zegarra et al., 2025; Qu et al., 2025).

Engagement and sustained focus are enhanced by gamification and immersive environments (Virtual and Augmented Reality) that integrate motivational and sensory stimuli with selective attention. Cognitive tracking technologies (neurofeedback, eye-tracking, EEG) allow for real-time intervention and immediate adjustments to strategic activities by monitoring the student's attentional focus (Ansari et al., 2025). Thus, cognitive skills can be enhanced by the neuroplasticity that underpins this process, remodeling synaptic connections. Challenges, engagement, repetition, and dynamics in inclusive environments reduce mental wandering (Table 1) and strengthen sustained attention (Xia et al., 2024; Gacek et al., 2025).

Attention is a strong predictor of academic performance, particularly in critical thinking and problem-solving situations. It can be trained using technologies that stimulate focus, memory, and reasoning (King et al., 2023; Gacek et al., 2025). However, mental wandering can be induced by strenuous activities that reduce concentration (monotonous reading and testing), increase fatigue, anxiety, executive and metacognitive deficits (difficulty monitoring thoughts), and compromise cognitive self-regulation. but can be mitigated by the conscious use of technologies (Al-Abyadh et al., 2024; Sharzad et al., 2024).

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For Shekouh et al. (2024), technologies support attentional monitoring and assist teachers in creating strategies for metacognitive personalization of learning. Still, it can generate cognitive superficiality when teaching planning is fragmented and limited to only gamification or immediate stimuli. It requires contextualized involvement and a balance between the type of attention and the sensory style of the student to ensure meaningful learning, as corroborated by Lagoudakis et al. (2024).

AI has evolved significantly by creating new technologies based on the principles of cognitive connectomes with a focus on attention. This approach is called neuro-inspired AI, allowing hypotheses about attention, memory, and human behavior to be tested. Brain-inspired neural networks elucidate mechanisms of information storage and retrieval. *Neuron AI* platforms exemplify neurocomputational systems aimed at behavioral analysis, neural simulation, and the prediction of attentional patterns. Brian2 is a Python platform for modeling and simulating neural networks. These are technological tools of behavioral neuroscience (Zegarra et al., 2025; Gkintoni et al., 2025; Qu et al., 2025; Shiwlani et al., 2024).

Connecting new knowledge, experiences, and technological innovations promotes creativity, giving students autonomy over their own learning. Gamification and adaptive feedback promote learning by making the process personalized and motivating. Neurofeedback, a non-invasive technique that monitors and regulates brain activity in real time during learning, helps individuals perceive and understand responses from the body and mind, improving and developing self-regulation and self-awareness skills (Dousset et al., 2025; Gacek et al., 2025).

fMRI, EEG, and EMT neuroimaging technologies deepen our understanding of the neural connectome, revealing how interventions modulate processes underlying attention and organize brain dynamics in learning (Shiwlani et al., 2024; Dousset et al., 2025). In this context, the integration of AI in education faces challenges due to the scarcity of systematic studies, but, at the same time, technological advances in fMRI expand knowledge about the brain and overcome limitations. Functionconnectome technology is an example of this, combining fMRI and structural connectivity to map axon function in vivo, clarifying how such connectivity supports attention and memory. All of this inexorably favors personalization in education, adapting methods, pace, and content based on evidence (Martín-Signes et al., 2024; Lagoudakis et al., 2024).

Intense interaction with digital technologies imposes multiple attentional and competitive demands on focus (visual, auditory, and emotional stimuli), with complex effects, affecting learning depending on exposure, time, and content. Limits, consistency, and balance in the use of technologies are necessary to preserve mental health, attention quality, and learning. Support tools such as Learning Analytics that use Big Data to identify performance patterns or impairments and guide the improvement of educational decisions converging with the most appropriate and effective IT (King et al., 2023; Hernández-Chávez et al., 2025).

King et al. (2023) investigated the relationship between selective attention skills, learning, and demands mediated by audiovisual resources in 107 students. They found that irrelevant visual elements can disperse focus and compromise the quality of learning, while targeted tutoring in the use of technologies promotes attention and concentration. Personalized teaching mediation is essential to reduce distractions and optimize student attention. Another study examined the neural circuits involved in alertness, orientation, and execution through in silico neuroimaging, concluding that connectome integration plays a central role in the predictive attentional modulation of behavior during learning (Martín-Signes et al., 2024).

Therefore, the thematic convergence of this study, related to the brain connectome, has advanced in the educational field in recent years. Of particular note are the essential tools for data analysis, modeling, visualization, and interpretation, revolutionizing neuroscience and education. The present study analyzed the substantial contributions of AI and DT to the understanding of attentional connectivity in learning, highlighting the convergent potential between attentional connectome, education, and intelligent technologies. Thus, neurolearning, which connects advances in CN to educational practices and combines technological tools, expands and adapts teaching to the contemporary revolution. This approach optimizes learning processes by using digital tools such as AI, AR, and VR to stimulate different areas of the brain in order to enhance content retention and engagement (Kamalov et al., 2023; Matias et al., 2025).

Despite the number of studies, new approaches are still needed on the applicability and effects of IT and neurolearning in the educational field. The growing interest in the brain as an organ of learning highlights the importance of attentional cognition. The limitations of this study include the restricted selection of specific journals and predefined time criteria, which may exclude relevant data. Despite the effort to ensure the objectivity of the research, some important studies may not have been considered.

5 FINAL CONSIDERATIONS

The convergence between cognitive neuroscience and digital and AI technologies has broadened our understanding of brain mechanisms and models applicable to learning. Studies on the attentional connectome favor the development of more accurate applications, enhancing learning and the human-machine relationship. However, such advances require collaborative reflection to ensure ethical implementations in the educational context.

Evidence about brain functions guides more effective and faster study practices and requires teachers to adopt educational approaches that integrate cognitive attention as a central axis of planning. This promotes greater efficiency, equity, and educational quality, integrating innovative curricula, meeting contemporary demands, and favoring more inclusive environments. Therefore, it is up to the educational system - managers, teachers, and other actors - to explore the potential of this interface in a strategic and ethical manner, consolidating a new educational design.

6 REFERENCES

ABISHEV N. et al. Artificial intelligence model in the cognitive and learning activities of university subjects. *Front. Education*, n.10, p.1623170, 2025. doi: 10.3389/feduc.2025.1623170

AL-ABYADH, M. H. A. et al. Do Smartphone Addiction and Self-Regulation Failures Affect Students' Academic Life Satisfaction? The Role of Students' Mind Wandering and Cognitive Failures. *Psychology research and behavior management*, v.17, n.02, p.1231-1253, 2024. doi.org/10.2147/PRBM.S437076

ANSARI, S.R.; QAMARI, I.N. Artificial intelligence and students' cognitive learning outcomes with bibliometric and content analysis for future research agenda. *Discovery Education*, n. 4, p.441, 2025. doi.org/10.1007/s44217-025-00865-0

BADRULHISHAM, F.; POGATZKI-ZAHN, E.; SEGELCKE, D. et al. Machine learning and artificial intelligence in neuroscience: A primer for researchers. *Brain, Behavior, and Immunity*, v. 115, p. 470-479, 2024. doi.org/10.1016/j.bbi.2023.11.005.

CHEN, Z.; YADOLLAHPOUR, A. A new era in cognitive neuroscience: the tidal wave of artificial intelligence (AI). *BCM Neuroscience*, v. 25, n. 1, p.15-22, 2024. doi:10.1186/s12868-024-00869-w

DOUSSET, C. et al. Enhancing attentional processing through sensorimotor neurofeedback training: evidence from a placebo-controlled, double-blind, event-related potentials study. *Neuroimage Journal*, v.15, n. 324, p. 121608, 2025. doi:10.1016/j.neuroimage.2025.121608.

GACEK, M.; SMOLEŃ, T.; KRZYWOSZAŃSKI, Ł. et al. Effects of School-Based Neurofeedback Training on Attention in Students with Autism and Intellectual Disabilities. *J Autism Dev Disord*, n. 55, p. 2884-2895, 2025. doi.org/10.1007/s10803-024-06400-8

GKINTONI, E. et al. Challenging Cognitive Load Theory: The Role of Educational Neuroscience and Artificial Intelligence in Redefining Learning Efficacy. *Brain sciences*, v. 15, n. 2, p. 203, 2025. doi.org/10.3390/brainsci15020203

HERNÁNDEZ-CHÁVEZ A.; HAMUI-SUTTON L.; MUÑOZ-COMONFORT A. et al. Effect of the Use of Electronic Media on the Cognitive Intelligence, Attention, and Academic Trajectory of Medical Students. *Cureus*, v. 17, n. 2, p. e79513, 2025. doi:10.7759/cureus.79513.

HORIEN, C.; GREENE, A. S.; SHEN, X. et al. A generalizable connectome-based marker of in-scan sustained attention in neurodiverse youth. *Cerebral cortex New York*, v. 33, n. 10, p. 320-6334, 2023. doi.org/10.1093/cercor/bhac506

HOROWITZ-KRAUS, T.; KENETT, Y. N. et al. Lower engagement of cognitive control, attention, modulation networks and lower creativity in children while using ChatGPT: an fMRI study. *bioRxiv*, n. 10, p. 687207, 2025. doi.org/10.1101/2025.11.07.687207

KAMALOV, F.; SANTANDREU C. D.; GURRIB, I. New Era of Artificial Intelligence in Education: Towards a Sustainable Multifaceted Revolution. *Sustainability*, n. 15, p. 12451, 2023. doi.org/10.3390/sui1512451

KING, J.; MARCUS, T.; MARKANT, J. Individual differences in selective attention and engagement shape students' learning from visual cues and instructor presence during online lessons. *Scientific reports*, v. 13 n. 1, p. 5075, 2023. doi.org/10.1038/s41598-023-32069-7

KRAUZLIS, R.J.; WANG, L.; YU, G, K. What is attention? Wiley Interdiscip. Rev Cogn Sci, v. 14, n. 1 p. e1570, 2023. doi:10.1002/wcs.1570.

LAGOUDAKIS N.; VLACHOS F.; CHRISTIDOU V. et al. The Use of Brain Based Learning Elements in a Teaching Approach for Scientific Understanding of Biology Concepts. American Journal of Educational Research, v. 12, n. 7, p. 247-253, 2024. doi:10.12691/education-12-7-5

LI, Y. et al. Neural mechanisms of emotion-focused interventions: A meta-analytic review of fMRI studies. Neuroimage, v. 320, n. 15, p. 121469, 2025. doi.org/10.1016/j.neuroimage.2025.121469

MARTÍN-SIGNES ET AL. Integrating brain function and structure in the study of the human attentional networks: a functionnectome study. Brain Struct Funct, n. 229, p. 1665-1679, 2024. doi.org/10.1007/s00429-024-02824-1

MATIAS, A.G.C.; ROCHA, S.L.N.; DOROTEA, N.M.T.C. Convergências educacionais: neuroaprendizagem e inteligência artificial. (2025). Em SciELO Preprints. doi.org/10.1590/SciELOPreprints.12100

PETERS, M. et al. Scoping reviews in: Aromataris E, Munn Z, editors. JBI Manual for Evidence Synthesis. Adelaide: JBI. Ch. 11, 2020. Available at: <https://campusguides.lib.utah.edu/SystematicReviews/conduct-scoping-reviews>

QU S, QU YL, YOO K et al. Connectome-based Predictive Models of General and Specific Executive Functions. bioRxiv [Preprint], p. 619468, 2025. doi:10.1101/2024.10.21.619468.

SCHWARZ, K.; WELLS, A.; GILLER, F.; et al. Investigating the Neural Correlates of the Attention Training Technique Using a Novel fMRI Paradigm for Measuring Attentional Control. Hum Brain Mapp, v. 46, n. 17, p. e70416, 2025. doi:10.1002/hbm.70416.

SHAHZAD, M. F.; XU, S.; LIM, W. M. et al. Artificial intelligence and social media on academic performance and mental well-being: Student perceptions of positive impact in the age of smart learning. Heliyon, v. 10, n. 8, p. e29523, 2024. doi.org/10.1016/j.heliyon.2024.e29523

SHEKOUH D.; SADAT K. H.; GHAFARZADEH-ESFAHANI M. et al. Artificial intelligence role in advancement of human brain connectome studies. Journal Frontiers in Neuroinformatics, v. 18, p. 01-09, 2024. doi:10.3389/fninf.2024.1399931

SHIWLANI, A.; HASAN, S.U.; KUMAR, S. Artificial Intelligence in Neuroeducation: AI Applications Aligned with Neuroscience Principles for Optimizing Learning Strategies. Journal of Social Sciences Development, v. 5, n. 4, p. 578-593, 2024. doi:10.47205/jdss.2024(5-IV)50

XIA, R.; CHEN, X.; ENGEL, T. et al. Common and distinct neural mechanisms of attention, Trends in Cognitive Sciences, v. 28, n. 6, p. 554-567, 2024. doi.org/10.1016/j.tics.2024.01.005.

YANG, J. et al. Intelligent technologies in smart education: a comprehensive transformative pillars and their impact on teaching and learning methods. Humanit Soc Sci Commun, n.12, p.1239, 2025. doi.org/10.1057/s41599-025-05444-0

WEIGARD, A.; ANGSTADT, M.; TAXALI, A. et al. Flexible adaptation of task-positive brain networks predicts efficiency of evidence accumulation. *Commun Biol.*, v. 7, n 1, p. 801, 2024. doi:10.1038/s42003-024-06506-w.

ZEGARRA, R.; CACERES-NAKICHE, L.E.; CARCAUSTO-CALLA, K. et al. Transforming university teaching with the use of artificial intelligence: opportunities and challenges. *Journal InveCom*, v. 5, n. 2, p. e502050, 2025. doi.org/10.5281/zenodo.13386114