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ICT mediation aimed at developing cognitive processes in adolescents

Mediación TIC orientada al desarrollo de procesos cognitivos en adolescentes

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Abstract

This paper presents a systematic review of the literature aimed at analyzing the importance of Information and Communication Technology (ICT) mediation in adolescent cognitive development. The initial phase was based on the PICO strategy for defining the research question and establishing the theoretical and conceptual framework. Following the criteria outlined in the PRISMA statement for document search and selection, seven scientific articles that met the inclusion standards were identified and categorized. The findings reveal the dichotomous nature of ICT in the current social context: they act as an enabler of cognitive development in controlled mediating environments, but simultaneously operate as an obstructor of higher metacognitive processes. It is concluded that the immediacy and simplified access to information provided by digital tools are displacing depth of thought, limiting the capacity for analysis and the structuring of complex knowledge in minors.

Keywords: cognition, technology, mediation, cognitive process, ICT

Resumen

Se presenta una revisión sistemática de la literatura orientada a analizar la importancia de la mediación de las Tecnologías de la Información y la Comunicación (TIC) en el desarrollo cognitivo adolescente. La fase inicial se fundamentó en la estrategia PICO para la delimitación de la pregunta de investigación y la conformación del marco teórico-conceptual. Siguiendo los criterios de la declaración PRISMA para la indagación y selección documental, se categorizaron 7 artículos científicos que cumplen con los estándares de inclusión. Los hallazgos revelan la naturaleza dicotómica de las TIC en el contexto social actual: actúan como un factor potenciador del desarrollo cognitivo bajo ambientes mediadores controlados, pero operan simultáneamente como un obstructor de procesos metacognitivos superiores. Se concluye que la inmediatez y el acceso simplificado a la información facilitado por las herramientas digitales están desplazando la profundidad del pensamiento, limitando la capacidad de análisis y la estructuración del conocimiento complejo en los menores.

Palabras clave: cognición, tecnología, mediación, proceso cognitivo, TIC

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INTRODUCTION

Today, society is undergoing structural transformations in the political, educational, and economic spheres, driven by rapid technological advances. This dynamic poses significant challenges for human adaptation and evolution in the face of constant change (Vergel et al., 2021). In this scenario, secondary school students experience various difficulties in the development of their cognitive processes, raising questions about the role of technology in shaping the adolescent mind (Perilla et al., 2019).

Evidence suggests that the excessive and unregulated use of technological tools outside controlled environments has led to a decline in the metacognitive processes of the digital native generation (Arráez, 2020). Although this decline is closely linked to social influences and lifestyles, the teaching-learning process is presented as a dichotomous consequence of technological influence (Llanga et al., 2019). On the one hand, overexposure to electronic devices and the omnipresence of social media generate distractions that undermine the ability to concentrate and devote oneself to academic tasks, thus limiting the depth of critical thinking (Araujo, 2022; García & Montero, 2020).

Likewise, information saturation in digital environments can lead to cognitive overload (Díaz et al., 2021). Students face difficulties in discerning between relevant and irrelevant information, which hinders their ability to synthesize and analyze effectively (Correa, 2022). Added to this is technological immediacy, which promotes a mindset of instant gratification that reduces perseverance in complex tasks and long-term problem solving (García, 2022; Rivas et al., 2014).

In contrast, the mediation of Information and Communication Technologies (ICT), when oriented toward cognitive development, is an invaluable tool for contemporary education (Muñoz et al., 2023). ICT offers resources that enrich learning and foster intellectual curiosity through access to digital libraries and specialized databases (Girona et al., 2021; Saavedra, 2020). In addition, they facilitate interactive and collaborative environments that promote communication skills and critical thinking (Arauz et al., 2022; Zavala et al., 2021). A key advantage of this mediation is the ability to personalize through adaptive programs, allowing adolescents to progress at their own pace and reinforce specific areas of difficulty (Freré et al., 2022b; Valbuena et al., 2021).

In summary, technology stands as an ambivalent factor in adolescent cognitive processes, representing both a strategic advantage and a structural challenge for the knowledge society. Given this duality, the present study aims to conduct a systematic review of the literature, using the PICO strategy and the PRISMA method, to answer the following research question: How does ICT mediation affect the development of cognitive processes in adolescents?

METHODS

This research was developed using a systematic literature review approach. The PICO strategy (Population, Intervention, Comparison, and Outcomes) was used to construct the theoretical-conceptual framework and delimit the object of study, which allowed us to structure the research question and define the key descriptors.

Search strategy and information sources

A systematic search was carried out in high-impact databases: PubMed, Scopus, Redalyc, Dialnet, and Journal ORG. The search was performed using a combination of controlled descriptors and free terms, including: Cognition, Cognitive Process, Apraxia, and ICT (a term validated in the absence of DeCS due to its thematic relevance). To optimize the accuracy of the results, Boolean operators (AND/OR) were used, allowing for effective intersection between the study variables.

Inclusion criteria and procedure (PRISMA)

The document selection process was governed by the PRISMA statement, ensuring traceability and transparency in the classification of articles. The following quality filters were applied:

Age window: Documents published in the last 5 years to ensure the validity of the findings.

Language: Articles in Spanish and English.

Type: Original studies, reviews, and peer-reviewed research articles. Finally, after the identification, screening, suitability, and inclusion stages, a final sample of seven documents was consolidated for qualitative analysis and thematic categorization.

RESULTS

Table 1

PICO question

Population (P)	Intervention (I)	Comparison (C)	Results (O)
Adolescents in need of cognitive development	Incidence of ICTs	_____	ICT mediation aimed at developing cognitive processes in adolescents

Source: own elaboration.

Question: How do ICTs affect the development of cognitive processes in adolescents?

Based on the PICO classification and the question, a search was conducted for the conceptual bases in the various databases mentioned, using the HEALTH SCIENCE DESCRIPTORS (DeCS) as direct references, as shown in the following matrix.

Table 2

Terminological review based on DeCS

Terms derived from the research	DeCS
Cognition	An intellectual or mental process through which an organism acquires knowledge.
ICT	No DeCS
Metacognition	Awareness and understanding of one's own thought processes.
Cognitive processes	No DeCS (directly related to cognitive psychology).
Apraxia	A group of cognitive disorders characterized by the inability to perform previously learned skills that cannot be attributed to motor or sensory function deficiencies.

Source: own elaboration.

With the information gathered by DeCS, convergent mediation is carried out between the different definitions (Gavilanes et al., 2019). The cognitive development of adolescents has been significantly influenced by Information and Communication Technologies (ICTs) in the learning process (Pimiento et al., 2020). These digital tools offer unprecedented access to information and educational resources,

which can enrich their knowledge and skills (Cupe et al., 2020). ICTs facilitate more interactive and dynamic learning, with the possibility of customizing content according to the needs and preferences of each student (MinTIC, 2020). Furthermore, they promote autonomy and problem-solving skills, as adolescents can research and resolve questions independently. However, there are also challenges associated with the excessive use of ICTs, such as distraction and access to unverified information (Díaz et al., 2019).

Based on this theoretical and conceptual framework, variables are combined or crossed to generate a matrix of equations that were used in the various databases explored.

Table 3

Combination or variables cross-referencing

Variable I	Variable II
Information technology and communication	Metacognition
Information technology and communication	Math skills
Information technology and communication	Conscience
Information technology and communication	Apraxia

Source: own elaboration.

By crossing variables, equations were generated that enabled a coordinated search for meta-analyses related to the question at hand, resulting in the following:

Table 4

Search equations

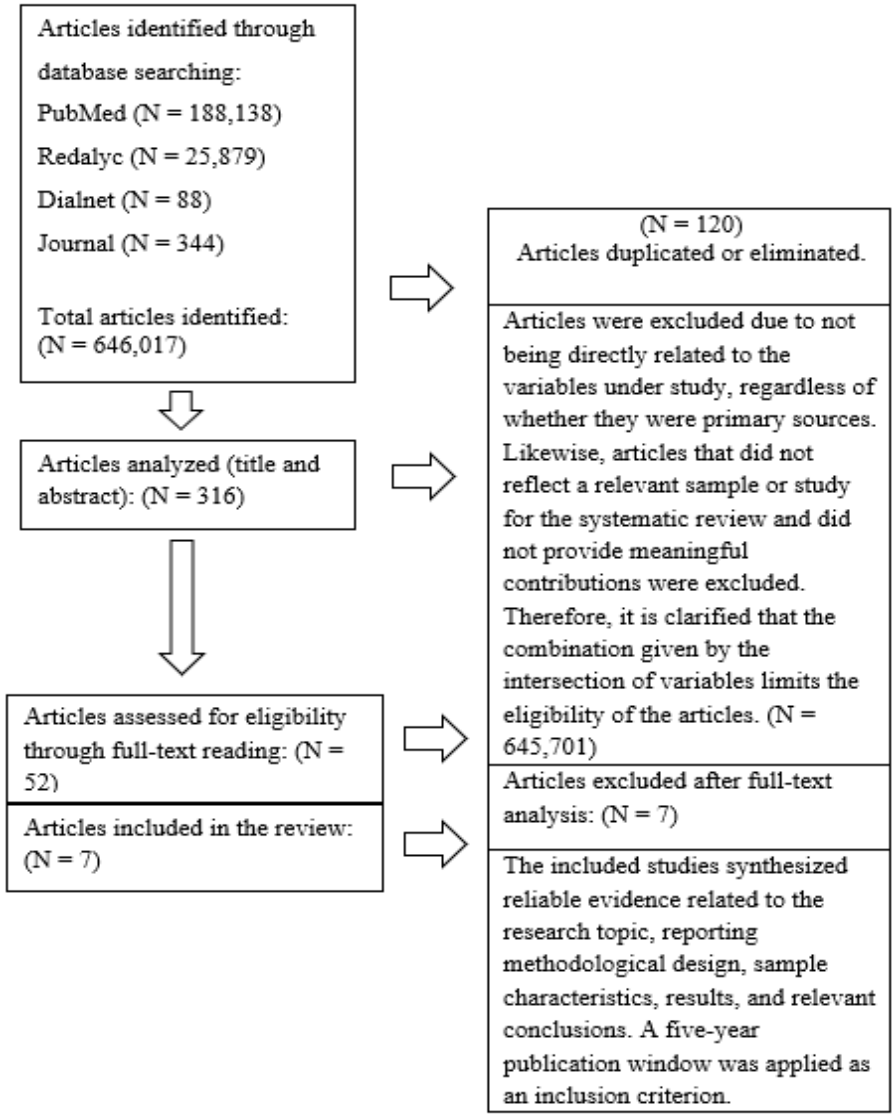
	EQUATIONS	
1	("Adolescents") AND ("Information technology and communication") AND ("Metacognition")	Adolescents AND Information technology AND communication AND Metacognition
2	("Adolescents") AND ("Information technology and communication") AND ("Math skills")	Adolescents AND Information technology AND communication AND Math skill
3	("Adolescents") AND ("Information technology and communication") AND ("Conscience")	Adolescents AND Information technology AND communication AND Math skill
4	("Adolescents") AND ("Information technology and communication") AND ("Apraxia")	Adolescents AND Information technology AND communication AND Apraxias

Source: own elaboration.

After cross-referencing the variables, the inclusion and exclusion criteria are applied according to the same parameters generated by the equations, seeking to identify the fundamental basis for this systematic review through them. The entire research process is summarized in the PRISMA diagram (Figure 1) and the data consolidation matrix (Matrix 5) presented below.

Figure 1

PRISMA flow diagram



Source: own elaboration.

Table 5

Search consolidation

Database	Total found	Document type	Time period	No access	Revisions/incomplete texts/duplicates	Failure to meet variable criteria	Total sample
PUBMED	188,138	0	0	53,331	0	132,807	2
REDALYC	25,879	0	0	0	0	25,877	2
DIALNET	88	0	0	0	0	85	2
JOURNAL.ORG	344	47	0	0	120	182	1
TOTAL	646,017	47	0	53,331	120	425,684	7

Source: own elaboration.

As part of the systematic construction process, the count of articles related to the study topic reached a peak of 646,017 research papers, which were subjected to a set of criteria categorized as follows: I) Keywords from any of the concepts derived from DeCS II) Meta-analyses and non-experimental descriptive studies conducted on adolescents III) Inclusion in databases of indexed articles. Of the total unfiltered number, a reduction of more than 90% was achieved, with only 7 fully complying with the variables set out. In addition, a filter of no more than five (5) years old (2018-2023) was used, which, as the categorization was applied, significantly reduced the initial total.

Based on the data and information obtained from the systematic review, the theoretical-conceptual results point to a description that starts from the cognitive process influenced by ICT in adolescents, providing an evaluation based on the results of the analyses carried out by the authors, as well as the reliability of use in this study.

Of the seven studies characterized, the process of contributing to the entire study is permeated with cognitive evidence of the influence of technologies on adolescent thinking, in such a way that it shows the pure interest of its researchers in addressing this issue from an educational perspective.

In this sense, the theoretical-conceptual realization leads to the understanding that technologies have traditionally been used as conveyors of information, communicators of knowledge, or tutors for students (Rodrigues et al., 2022). In the field of educational communications, it is based on the premise that communicating content to students will result in learning (Morales et al., 2022; Vásquez et al., 2022). In educational communications, information or intelligence (in many different forms) is encoded visually or verbally in the symbol systems employed by each technology. During the "instruction" process, students perceive the messages encoded in the medium and, at some point, "interact" with the technology (Muchiut et al., 2021). Interaction is typically implemented in terms of student input to the technology, which triggers some form of response evaluation and technology response in the form of some pre-coded (canned) message (Restrepo et al., 2019). Technologies as transmitters of information have been used for centuries to "teach" students by presenting them with prescribed information that they are required to "learn."

Historically, educational communications have been developed and marketed to teachers by teams of educators, including instructional designers, subject matter specialists, media producers, and media managers (Vergel et al., 2021). Educational programs are designed using a variety of systematic instructional design models that have been recommended by experimental research based on very Western notions of causality and determinism (more on this later). This systematic process embodies the very definition of the field (Zabala et al., 2018). It holds that we can accurately predict the behavior and learning outcomes of organisms as complex as human learners. In this short article, I argue that these assumptions should be questioned, first for empirical reasons and second for philosophical reasons (Salcedo et al., 2022).

The first is easy: the overwhelming majority of unpublished research and the simple majority of published research in our field, in which we have used technology as transmitters or knowledge, have not produced "significant differences" (Abela & Pérez, 2011; Freré et al., 2022c) in learning as a result of their interventions. Why? Because we cannot accurately predict the behavior of complex organisms. Based solely on this empirical criterion, we should rethink the use of technology as a mediator of learning (Cordoba & Monsalve, 2021).

The second reason is philosophical. It is understood that the learning process is holistic. It cannot be understood simply by analyzing human responses to the attributes of the technologies that convey the messages to be learned. In fact, it is difficult, if not impossible, to isolate the effects of the possibilities

of technologies (Bilbao et al., 2022). Instructional design models are based on two essential components of reality, objectivity and causality, both of which are integral components of consciousness. Objective reality is based on a series of assumptions, such as the common perception that supposedly allows us to observe and describe the physical world and convey those descriptions to others as reality (Pertusa, 2022).

Computer technologies as cognitive tools represent a significant departure from traditional conceptions of technologies. In cognitive tools, information and intelligence are not encoded in educational communications that are designed to efficiently convey that knowledge to learners (Andrades et al., 2022). With cognitive tools, traditional design and development processes are eliminated. Instead of educational communication specialists using technologies to limit students' learning processes through prescribed communications and interactions, the technologies are taken away from the specialists and given to the students to use as a means to represent and express what they know. Students function as designers who use technology as tools to analyze the world, access information, interpret and organize their personal knowledge, and represent what they know to others (Minaya & Castro, 2021).

Cognitive tools are generalizable computer tools that are intended to engage and facilitate cognitive processing; therefore, cognitive tools (Merbilháa, 2018). Cognitive tools are both mental and computational devices that support, guide, and extend the thinking processes of their users. They are knowledge-building and facilitation tools that can be applied to a variety of subject areas (Aparicio, 2019b).

Cognitive tools and learning environments that have been adapted or developed to function as intellectual partners with the learner to engage and facilitate critical thinking and higher-order learning include (but are not necessarily limited to) databases, spreadsheets, semantic networks, expert systems, multimedia/hypermedia construction, computer conferences, collaborative knowledge-building environments, and, to a lesser extent, computer programming and microworld learning environments (Sanhueza et al., 2018). When students build knowledge bases with databases, expert systems, or semantic network tools, they must analyze subject domains, develop mental models to represent them, and represent what they understand in terms of those models (Aparicio & Ostos, 2018; Gómez & Albalat, 2021).

Conversely, there is an overlapping notion that expands between what is and what should be according to (Aparicio, 2019b), technological mediation. Technologies do not directly mediate learning. That is, people do not learn from computers, books, videos, or other devices that were developed to convey information. Rather, they learn. Thinking is mediated by thinking (mental processes). Thinking is activated by learning activities, and learning activities are mediated by educational interventions, including technologies (Aparicio, 2018). Learning requires the learner's thinking. Therefore, to more directly affect the learning process, we should be less concerned with the design of transmission technologies and more concerned with how learners are required to think when completing different tasks. Instead of developing increasingly powerful educational hardware, we should teach learners to think more effectively.

Hence, the significance of the premise that, in relation to cognitive processes, technology is its own counterpart.

CONCLUSIONS

In summary, today's society presents a number of challenges that affect the development of cognitive processes. From information overload to the culture of multitasking and stress, these challenges can undermine our ability to think deeply and develop strong cognitive skills. It is essential that as

individuals and as a society, we seek a balance between the use of technology and dedication to activities that promote critical thinking and reflection, to enhance our cognitive development in an increasingly complex world.

Furthermore, conducting a systematic review of the difficulties of cognitive process development in today's society is of vital importance. In the digital and technological age in which we live, our minds face unique and complex challenges. Examining these difficulties in a rigorous and structured manner allows us to better understand how today's society is affecting our ability to process information, make decisions, and solve problems.

To conclude, through the investigation carried out using the PRISMA method, we discovered the contradictory dichotomy of today's knowledge society, the constant contact that adolescents have with technology, making it increasingly difficult to control its vast range of influence, even though its use promises a wide range of benefits in terms of strengthening thought processes.

Future research should therefore approach this issue from a holistic perspective, particularly in the Spanish-speaking context, by promoting studies aimed at developing effective strategies for regulating ICT use.

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