

COGNITIVE DEVELOPMENT AND EDUCATIONAL TECHNOLOGIES



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ABSTRACT

This article examines the relationship between cognitive development and educational technologies, highlighting how the integration of these tools can significantly enhance the teaching-learning process. Neuroscience has played a crucial role in offering a detailed understanding of cognitive processes, providing valuable subsidies for the creation of more effective pedagogical practices adapted to the needs of students. Emerging educational technologies, such as augmented reality, virtual reality, and artificial intelligence, have shown great potential to make learning more interactive, dynamic, and personalized, meeting the particularities of each student. The literature review includes important contributions from renowned authors, such as Jean Piaget and Lev Vygotsky, who discuss the relevance of the environment and the use of technological tools in cognitive development, as well as other theorists who explore how these innovations can positively influence learning. The critical analysis of the article highlights both the opportunities and challenges of integrating these technologies, emphasizing the urgent need for continuing education for teachers and the importance of creating learning environments that promote collaboration, interaction, and student engagement.

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INTRODUCTION

The relationship between cognitive development and educational technologies has been the subject of study and debate among researchers and educators. Neuroscience, by providing a detailed understanding of cognitive processes, offers valuable tools to improve pedagogical practices.

Emerging educational technologies, such as augmented reality, virtual reality, and artificial intelligence, have the potential to transform learning, making it more interactive and personalized. This article seeks to explore how the integration of these technologies can positively influence the teaching-learning process, highlighting the importance of continuing education of teachers and the creation of positive learning environments.

Neuroscience has shown that the human brain is highly plastic, capable of adapting and reorganizing itself in response to new experiences and learning. This brain plasticity is critical for cognitive development, allowing individuals to acquire new skills and knowledge throughout their lives. Educational technologies can enhance this process, offering rich and diverse learning experiences that stimulate different areas of the brain.

Augmented reality, for example, allows students to interact with digital content superimposed on top of the real world, creating an immersive and engaging learning experience. Virtual reality, in turn, offers the possibility of exploring three-dimensional virtual environments, providing a deeper understanding of complex concepts. Artificial intelligence can be used to personalize learning, adapting the content and pace of teaching to the individual needs of each student.

However, the integration of educational technologies in the teaching-learning process is not without challenges. It is necessary for teachers to be prepared to use these tools effectively, which requires continuous training and constant updating. In addition, it is essential to create learning environments that favor interaction and collaboration, promoting active and meaningful learning.

This article reviews the existing literature on the subject, presenting contributions from renowned authors who discuss the importance of the environment and technological tools in cognitive development.

The critical analysis addresses the challenges and opportunities of this integration, emphasizing the need for a balanced approach that considers both the benefits and limitations of educational technologies.

RESEARCH METHODOLOGY

The methodology of bibliographic review is an essential component in academic research, as it enables a critical and comprehensive analysis of the current state of knowledge in a specific area.

This process involves several fundamental steps: the definition of clear objectives, the systematic search for relevant sources, the critical evaluation of the studies and the synthesis of the information found. These steps are crucial to ensure that the review provides a complete and accurate picture of the topic at hand.

According to Creswell (2014), a well-executed literature review begins with the formulation of precise research questions and the definition of specific criteria for the selection of studies, where he highlights that clarity in the definition of research questions is vital to guide the search for sources and ensure that the review addresses all relevant perspectives. He emphasizes the importance of a systematic approach to minimize bias and promote a comprehensive understanding of the topic. This includes the careful choice of studies and the organization of information in order to reflect the complexity of the subject analyzed.

Following this line of thought, Petticrew and Roberts (2006) emphasize the need for an extensive and rigorous search, using multiple sources and databases to ensure the inclusion of all pertinent evidence. They point out that transparency in the process of selecting and excluding sources is crucial to the credibility of the review.

Clear documentation of the search and selection stages not only contributes to the replicability of the search, but also strengthens confidence in the results presented. Petticrew and Roberts suggest using systematic strategies, such as searching for key terms and defining inclusion and exclusion filters, to ensure that the review is comprehensive and well-founded.

Kuhlthau (1993) also offers significant contributions to the methodology of literature review by emphasizing the importance of critical analysis of the selected sources, commenting that it is essential to evaluate the quality and relevance of the studies included in the review.

She argues that the analysis should be reflective and analytical, ensuring that the conclusions are based on robust and current evidence, arguing that the review should go beyond the simple synthesis of information, promoting a deep analysis that considers the validity of the methods and the applicability of the results of the reviewed studies.

Therefore, the literature review methodology must follow a structured and rigorous process, as described by Creswell (2014), Petticrew and Roberts (2006) and Kuhlthau (1993), offer valuable guidelines to carry out an effective review, ensuring that the analysis is complete, critical and well-founded, where the donation of these practices not only improves the quality of the review, but also contributes to the production of a solid and reliable academic work.

LITERATURE REVIEW

PIAGET (1970)

Jean Piaget is one of the leading names in the field of developmental psychology and his theories on cognitive stages offer an important basis for understanding how learning occurs. Piaget proposed that cognitive development happens in a sequence of stages (sensory-motor, pre-operational, concrete operations and formal operations), each characterized by different ways of thinking and interacting with the world.

Educational technologies, such as interactive tools and simulation software, can be used to create learning experiences that correspond to these stages, facilitating the transition between them. For example, students in the early stages, who rely more on concrete experiences, can benefit from technologies that offer virtual manipulation of objects, helping them to actively build knowledge.

In a modern educational context, it is possible to apply this theory using augmented reality to create concrete experiences in a digital environment, allowing children to explore and manipulate the virtual world while developing specific cognitive skills.

In addition, the active construction of knowledge, central to Piaget's theory, is facilitated by technologies that encourage exploration and discovery. Game-based educational software, for example, promotes problem-solving and allows students to test their hypotheses interactively.

However, one challenge that Piaget would likely point out regarding the use of technology would be the need to ensure that students are prepared for the complexity of the tools used. That is, technology should be used in a way that complements the student's cognitive stage, and does not overload their ability to assimilate.

VYGOTSKY (1978)

Lev Vygotsky, with his sociocultural theory, emphasized the fundamental role of social interaction in cognitive development, arguing that learning happens within a social and cultural context, and that mediation tools, including language and technologies, play a vital role in this process.

His Zone of Proximal Development (ZPD) theory, which describes the distance between what a child can do on their own and what they can accomplish with the help of a mediator, is especially relevant in the age of educational technologies. Technologies, such as collaborative learning platforms and virtual tutors, can act as mediators, extending the reach of individual learners' capabilities and promoting collaborative learning.

The role of educational technologies, in this case, goes beyond the mere transmission of content. Tools such as intelligent tutoring systems and virtual learning environments allow students to work as a team, receive instant feedback, and get real-time support, enabling advancement within ZPD.

The use of technology as a mediator between the knowledge that students already have and what they can develop can strengthen the construction of knowledge more effectively than traditional methods.

However, one challenge pointed out by Vygotsky would be the need to ensure that educational technologies continue to support real social interaction, rather than isolating them in a purely digital environment.

GARDNER (1983)

Howard Gardner, with his theory of multiple intelligences, proposed that individuals have different types of intelligence — linguistic, logical-mathematical, spatial, musical, bodily-kinesthetic, interpersonal, intrapersonal, and naturalistic — and that educational practices must be adapted to meet this diversity.

Educational technologies can be a powerful tool for personalizing learning and catering to diverse forms of intelligence. An example would be the use of software that stimulates logical-mathematical thinking through reasoning games, while other technological tools, such as graphic design or musical composition programs, can encourage spatial and musical intelligence, respectively.

Gardner would argue that educational technologies offer students an unprecedented opportunity to engage in practices that match their strengths; However, it is essential that

educators know how to identify these intelligences and use the appropriate technologies to enhance them. Furthermore, Gardner's approach suggests that technology should be used as a tool to broaden each student's repertoire, providing learning opportunities that would otherwise not be available in a traditional setting.

One challenge is to ensure that the implementation of these technologies is not standardized, but rather flexible and tailored to the individual needs of students.

BRUNER (1966)

Jerome Bruner, with his constructivist approach to learning, emphasized that students actively build their knowledge through discovery and exploration, where he proposes that instruction should be organized in such a way that students can explore and discover on their own, with the support of a framework that guides them through the learning process.

The use of educational technologies, such as simulations and virtual learning environments, can be an excellent way to implement Bruner's theory, allowing students to test hypotheses and experiment in a controlled and safe environment.

Bruner also emphasized the importance of offering relevant and immediate feedback, which is something that educational technologies such as smart tutors or educational games can do effectively. Tools that encourage experimentation and offer immediate responses help students reflect on their actions and adjust their learning strategies.

One challenge, however, is to ensure that students are truly engaged in the discovery process and not just follow predefined scripts on educational platforms, which could limit the creative and exploratory potential advocated by Bruner.

PAPERT (1980)

Seymour Papert, a pioneer in the field of education and technology, was one of the first to advocate the use of computers as a tool for active learning. He developed the LOGO programming language, which allows students to learn math and problem-solving concepts through programming.

For Papert, educational technologies have the power to transform education by allowing students to be active creators of knowledge, rather than passive receivers. This

view is even more relevant today, with the emergence of new technologies such as block programming, which makes it easier for students to enter the world of coding.

This author argued that educational technologies should not only be tools to teach what is already known, but to help students explore the unknown and build new knowledge.

He was also a strong advocate of project-based learning, where students work on real problems and use technology to find creative solutions, where one challenge identified by Papert would be to ensure that technologies are used in a way that stimulates critical and creative thinking, and not just to facilitate the consumption of information.

MORAN (2000)

José Moran discusses the integration of educational technologies into the school curriculum and argues that they can make learning more meaningful and relevant. Moran highlights the importance of continuing education for teachers, pointing out that the success of the implementation of technologies depends on the ability of teachers to adapt them to the needs of students and the pedagogical context. He proposes the creation of learning environments that favor interaction, collaboration, and student autonomy, using technologies as mediators of this process.

Moran also emphasizes the importance of curriculum planning that intentionally incorporates educational technologies, ensuring that they are used to enrich the teaching process and not just as a superficial complement. One concern raised by Moran is the possible disparity between schools and teachers in terms of access to and knowledge about new technologies, which could create a digital divide between different groups of students.

ZEINAB ZAREMOHZZABIEH ET AL. (2024)

Zaremohzzabieh and his team conducted detailed research on the relationship between educational technologies and the development of creative thinking. In their meta-analysis published in 2024, they investigated how technological tools such as educational games and interactive tools can influence different aspects of creative thinking, such as fluency, flexibility, and originality. The team of researchers reviewed a wide range of studies examining the effectiveness of digital technologies in promoting advanced cognitive skills among students of diverse ages and educational backgrounds.

One of the main conclusions of the study is that interactive educational technologies allow for more active and engaging learning, encouraging student participation in activities that require creative thinking and problem-solving. By using tools such as augmented and virtual reality, students are exposed to scenarios that allow them to explore ideas in a more in-depth way, applying the knowledge acquired in new and innovative ways. Interaction with these tools increases cognitive plasticity, helping to expand students' ability to think critically and creatively.

However, Zaremohzzabieh also points out that the effectiveness of these technologies depends heavily on how they are implemented by educators. Teacher training and capacity building are key to ensuring that technologies are used in a way that maximizes their potential.

The authors highlight the need for educators to adopt a balanced approach, combining the use of digital tools with traditional teaching methods that promote reflection and metacognition.

In addition, the study explores how collaboration among students can be encouraged through digital environments. Educational tools that facilitate group work, such as online learning platforms, create opportunities for the exchange of ideas and the collective construction of knowledge, which is essential for the development of creative thinking.

Thus, it concludes that educational technologies, when used appropriately, can significantly transform the learning environment, promoting the development of superior cognitive skills that are fundamental in the modern world.

VIP GUPTA (2023)

Vipul Gupta and his team published research in 2023 that explores the role of artificial intelligence (AI) in personalizing learning and developing cognitive skills, particularly in areas such as programming and logical thinking.

Gupta's team argues that AI can transform the educational environment by offering adaptive learning solutions, adjusting the content and pace of lessons based on the individual needs of students.

The research highlights that AI platforms have the ability to analyze students' learning patterns in real-time, offering immediate feedback that allows students to adjust their study approaches and strategies.

This personalization is especially effective in teaching technical skills such as coding, where the pace of learning can vary significantly from student to student.

In addition, AI facilitates self-directed learning, allowing students to take greater control over their learning process, exploring additional content according to their curiosity and interests.

Gupta also explores the challenges associated with implementing AI in educational settings; While technology offers significant promise, training educators to use these tools is a crucial aspect of their success. Many teachers face difficulties in adapting their methodologies to integrate AI technologies effectively.

Therefore, Gupta defends the need for continuing education programs that enable teachers to use AI not only as a support tool, but as an integral part of their pedagogical plan.

Another important aspect addressed by Gupta is the issue of equity in access to AI technologies, where he points out that, although AI has the potential to democratize learning, there is also a risk of widening educational inequalities if access to these technologies is limited to certain regions or socioeconomic groups.

The research team suggests that governments and educational institutions should invest in policies that ensure equitable access to educational technologies, ensuring that all students can benefit from these innovations.

EDMUNDO TOVAR E NELSON PIEDRA (2023)

In 2023, Edmundo Tovar and Nelson Piedra published a groundbreaking study on the use of artificial intelligence technologies for the development of digital skills and their relationship with the needs of communities.

These authors argue that AI-based educational technologies can bridge the gap between the traditional curriculum and the demands of the modern labor market, especially with regard to the development of digital competencies such as programming, data analysis, and critical thinking.

Their studies focus on creating curricula that integrate digital tools and promote the inclusion of practical skills, preparing students for an increasingly automated and digital work environment.

The research also explores how AI can be used to personalize learning by tailoring lessons to students' individual capabilities and offering specific support for those who struggle in certain areas.

In addition, they discuss the importance of digital inclusion and equity in access to these technologies, arguing that educational institutions must ensure that all students, regardless of their socioeconomic background, have access to AI tools.

For them, the democratization of access to digital technologies is essential to avoid the expansion of educational inequalities and provide equal opportunities for success for all students.

Another key point of the research is the role of collaboration in the digital environment, where they highlight that AI tools can be used to facilitate collaboration between students, creating virtual learning environments in which students can share ideas, work on joint projects, and build knowledge collaboratively.

In this way, they concluded that, when applied correctly, AI-based educational technologies can not only improve academic performance, but also prepare students for the challenges of the contemporary professional world.

YONGBIN ZHANG E XIULI FU (2023)

Zhang and Fu published a detailed study in 2023, in which they examine the application of neuroscience-based cognitive theories in the context of distance learning, where the central focus of their research is on faculty presence in virtual environments, such as instructional videos, and how this can impact student performance in online learning environments.

Research suggests that direct interaction between teachers and students, even in virtual environments, is essential to increase engagement and promote more effective learning. The authors used neural theories to assess how different approaches to content presentation affect information retention and the ability to solve complex problems.

They found that the presence of teachers in instructional videos significantly increases student motivation and improves understanding of abstract concepts; and yet they have exploited the potential of virtual and augmented reality to create more immersive learning environments.

They argue that these technologies can be particularly effective in areas such as the sciences, where the visualization of complex concepts can be facilitated through interactive three-dimensional environments.

The authors also suggest that the integration of artificial intelligence tools into distance learning platforms can personalize learning by adjusting the content and pace of classes to the individual needs of students.

However, Zhang and Fu also warn of the challenges associated with the implementation of these technologies, highlighting that the infrastructure needed to support virtual and augmented reality platforms is not yet widely available in many regions, which may limit the reach of these innovations.

REVIEWS

The integration of educational technologies in the teaching-learning process presents both challenges and opportunities; if, on the one hand, technologies can enrich learning, offering interactive and personalized experiences that stimulate cognitive development; On the other hand, the effectiveness of these technologies depends on the preparation and engagement of teachers, as well as the creation of learning environments that favor interaction and collaboration.

The continuous training of teachers is essential for them to be able to use technologies effectively and integrated into the curriculum, and it is necessary that teachers are up to date on new tools and methodologies, and that they are able to adapt them to the needs and characteristics of students; certainly creating learning environments that promote interaction and collaboration, providing students with opportunities to work together and learn from each other.

Educational technologies, such as augmented reality, virtual reality, and artificial intelligence, have the potential to transform learning, making it more interactive and engaging, and it is essential that these technologies are used in a balanced way, considering both benefits and limitations, making students not become dependent on technologies, but use them as tools to support and enrich learning.

The critical analysis of the reviewed texts reveals that the integration of educational technologies in the teaching-learning process can promote cognitive development, as long as the needs and characteristics of students are considered, and that teachers are prepared to use these tools effectively.

Creating positive and collaborative learning environments is essential for students to be able to explore and build knowledge in an active and meaningful way.

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