

THE APPLICABILITY OF TECHNOLOGY IN TEACHING AND ITS IMPACT ON THE TEACHING AND LEARNING PROCESS OF CHILDREN WITH ADHD: A SYSTEMATIC REVIEW

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Abstract: The aim of this research was to analyze the applicability of technology in teaching and its impact on the teaching and learning process of children with Attention Deficit Hyperactivity Disorder (ADHD). To this end, a systematic review was carried out following the PRISMA guidelines. Searches were conducted in databases such as Scielo, Web of Science and Google Scholar, using specific terms, Boolean operators and inclusion/exclusion criteria to select articles in Portuguese published between 2020 and 2023. The analysis comprised two stages: an initial screening, covering titles and abstracts, and a complete screening, involving the full reading of the selected articles. As a result, 7 articles were selected, where it was possible to see that technology in teaching work contributes to arousing children's curiosity about the content covered in the classroom. In this sense, technological tools are capable of minimizing some of the classic symptoms of ADHD, such as hyperactivity and restlessness. It has been observed that gamification, brain-computer interfaces, educational software and virtual environments improve the performance and inclusion of these students. Thus, the use of technology in the school environment makes the teaching and learning process dynamic, providing an interactive environment with mutual participation between teachers and children with ADHD.

Key Word: Technology; teaching; learning; children; ADHD.

I. Introduction

Education is constantly evolving as new pedagogical approaches and technological tools emerge to meet the growing demands of society and the knowledge-based economy. In this context, technology presents itself as a disruptive force that is redefining teaching and learning practices. From the rise of mobile devices to the proliferation of online learning platforms and artificial intelligence, technology has demonstrated its potential to increase the effectiveness and accessibility of education at all levels (BRUZZI, 2016).

In the current educational scenario, Vieira Júnior and Melo (2021) emphasize that the intersection between technology and teaching has proved to be a transformative force of unparalleled magnitude. Technological advances, especially in the digital context, have brought with them a series of pedagogical innovations, offering new teaching and learning opportunities. In this context, a particularly relevant aspect is the application of technology in the education of children with Attention Deficit Hyperactivity Disorder (ADHD).

ADHD is a neurobiological disorder commonly diagnosed in childhood, characterized by attention deficits, hyperactivity and impulsivity. ADHD symptoms can persist into adulthood and affect various aspects, including

academic performance, social relationships and professional functioning. Treatment usually involves a multidisciplinary approach that includes behavioral therapy, education about the disorder and, in some cases, medication (ROHDE et al., 2019).

From this perspective, ADHD can have a direct impact on children's school life. Symptoms such as difficulty concentrating, impulsivity and hyperactivity can jeopardize academic performance and social interaction in the classroom. Because of this, children with ADHD often have difficulty following instructions, completing tasks and maintaining attention in learning activities (SOUZA et al., 2021).

According to information from the Brazilian Attention Deficit Disorder Association (ABDA) (2022), the prevalence of Attention Deficit Hyperactivity Disorder (ADHD) varies globally, between 5% and 8%. Among children with ADHD, 70 per cent have at least one other concomitant disorder, such as anxiety disorders, depression, learning difficulties, oppositional defiant disorder, among others. In addition, around 10 per cent of children with ADHD face the complexity of dealing with three or more comorbidities, which can make diagnosing and treating the disorder even more challenging.

ADHD can therefore have a negative influence on children's learning processes. This is because symptoms of inattention can make it difficult to understand content and complete school tasks. In addition, the presence of hyperactivity and impulsivity can adversely affect academic performance, participation in extracurricular activities and social interactions with peers and teachers. Therefore, it is essential to develop pedagogical strategies that contribute to children's development in the school context (ABRAHÃO et al., 2020).

Given this context, the aim of this research was to analyze the implications of technology for the teaching-learning process of children with ADHD. It is hoped that the results of this research will help educators, students and parents understand how technology can be used effectively to support the educational development and well-being of children with ADHD. In addition, it is hoped that the findings will contribute to the development of more effective strategies and approaches to the use of technology as an inclusive and adaptive pedagogical tool that meets the specific needs of these children, promoting academic and social development.

II. Material And Methods

This study consisted of a systematic review, which is a type of research that aims to synthesize, analyze and evaluate existing evidence in the scientific literature on a given topic (GALVÃO; RICARTE, 2019). It is therefore a research method that involves drawing up a prior protocol, carefully searching for relevant studies, carefully selecting the articles to be included, critically evaluating the methodological quality of these studies and synthesizing the results to provide a comprehensive and well-founded overview of the topic in question (BRIZOLA; FANTIN, 2017).

Thus, the systematic review sought to contribute to a more in-depth understanding of the implications of technology for the teaching and learning of children with ADHD, with the aim of identifying pedagogical practices and educational policies aimed at this population. The systematic review was carried out following the PRISMA guidelines, which are, according to Botelho, Cunha and Macedo (2011), a set of recommendations and guidelines developed for the preparation and presentation of systematic reviews in the scientific literature. These guidelines were created to ensure that these types of studies are conducted in a rigorous and transparent manner, allowing readers to critically assess the methods and results of the reviews.

The PRISMA guidelines provided a structured methodological procedure for drawing up the research protocol, identifying and selecting studies, assessing methodological quality, extracting data, analyzing the results and transparently presenting the information. This made it possible to provide a structure that promoted the integrity and reliability of the systematic review, ensuring that the research process was conducted carefully and that the results were reported clearly and objectively. This methodological rigor was essential to achieving the objectives set out in this review.

Data searches took place on three platforms: Google Scholar, Scielo and Web Of Science, which are considered comprehensive and reliable sources for identifying relevant studies related to the topic under study. The choice of these platforms aimed to ensure the inclusion of a wide variety of studies, covering different perspectives and approaches to analyzing the issue in focus.

To find the articles, keywords were used in association with the Boolean operators "AND" and "OR" using the following search sequence: ("technology") AND ("children with ADHD") AND ("school") AND ("teaching" OR "learning").

The "AND" operator was used to find studies containing all the specified keywords, which helped refine the search, ensuring that the results were strictly related to the topic of interest. On the other hand, the "OR" operator was used to broaden the search, allowing studies with any of the keywords to be included. This helped to cover a variety of perspectives and approaches related to the topic, ensuring a complete and representative view of the existing literature on the implications of technology in the teaching and learning of children with ADHD.

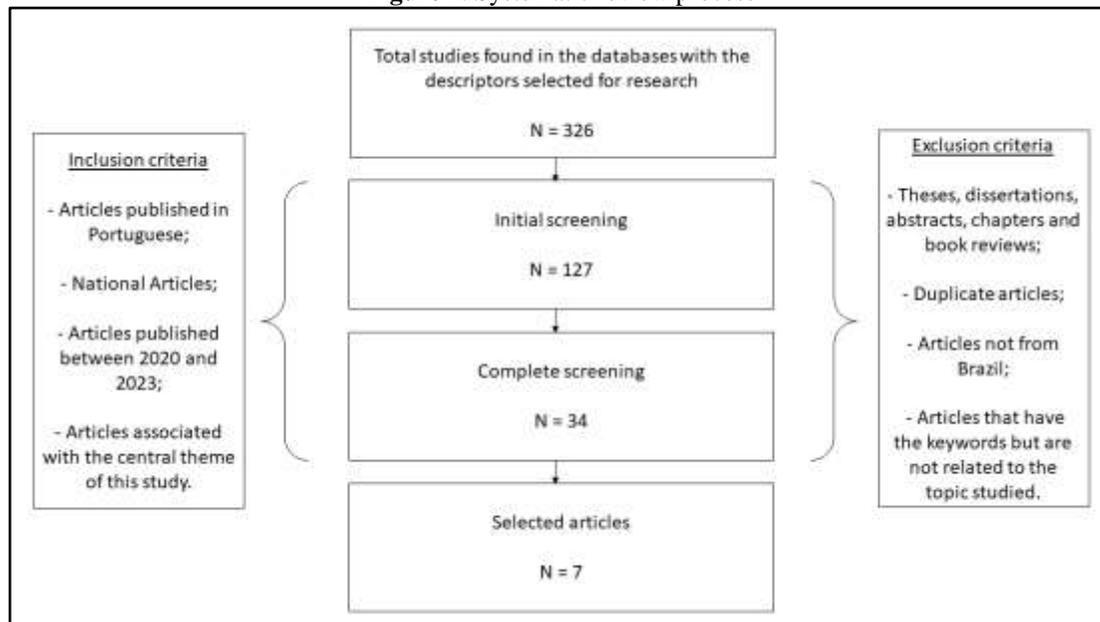
As inclusion criteria, specific guidelines were established for selecting the studies to be included in this systematic review. The inclusion criteria were defined in such a way as to guarantee the relevance and pertinence of the articles in relation to the research topic. Thus, only articles associated with the central theme of this study, published between 2020 and 2023, in Portuguese and of Brazilian nationality were considered.

The inclusion criteria were defined in such a way as to guarantee the relevance and pertinence of the articles in relation to the research topic, corroborating what Pitta and Castro (2006) suggest. These criteria were applied systematically during the study selection process, ensuring that only articles directly relevant to the research were incorporated into the review. In this way, we sought to maintain the quality and accuracy of the analysis, providing a comprehensive overview of the available evidence on the implications of technology for the teaching and learning of children with ADHD.

Exclusion criteria were established that included the exclusion of abstracts, dissertations and theses, with the aim of concentrating the review on complete studies that provided detailed information and in-depth analyses on the topic in question. In addition, it was decided to exclude articles published in Angola, Mozambique and Portugal in order to ensure that only studies of Brazilian nationality were considered, maintaining the relevance of the findings to the Brazilian educational context. Duplicate articles were also removed to ensure the integrity and accuracy of the analysis.

After conducting the searches using the inclusion and exclusion criteria, the articles were analyzed. The articles selected for this systematic review underwent an initial screening process, which involved reading the abstracts, followed by a full screening, which included reading the articles in full. This rigorous selection and screening process was key to ensuring that only the most pertinent and reliable studies were considered in the analysis. At the end of the analysis process, 8 articles were selected, as shown in figure 1.

Figure 1. Systematic review process



Source: Research data (2023).

The selected articles were carefully organized into a table, which served as an effective tool for summarizing and systematizing the essential information from each study. The systematic organization of the articles in this framework facilitated comparative analysis between the studies and allowed for a comprehensive

understanding of the trends, similarities and differences in the approaches and results found. This structured approach was fundamental to the transparent presentation of information and the development of critical analysis in the systematic review on the implications of technology for the teaching and learning of children with ADHD.

III. Result

The result of the systematic review was a sample of 7 scientific articles that addressed the applicability of technology in teaching and its impact on the teaching and learning process of children with Attention Deficit Hyperactivity Disorder (ADHD). Table 1 shows the articles selected in this systematic review.

Table 1: Articles selected in the systematic review

Authors	Research objective	Research conclusions
Lima, Brandão and Ferreira (2022)	Identify the learning difficulties of children with ADHD and point out technologies to help children with ADHD learn	The use of educational software has been shown to improve the learning process of students with ADHD. Some games provide a modern and dynamic teaching experience, capturing students' attention and resulting in an increase in their academic performance. In addition, it was observed that teachers already use some technological tools, such as computers and mobile phones, which allows the introduction of other free technologies, such as the games Kahoot, Duolingo, Perguntados, CodyCross, Voo Educativo, Mapa do Brasil, Mestre da Tabuada, Coleta Seletiva and Sistema Solar. This makes the lessons more attractive, thus improving the absorption of the content taught in the classroom.
Mendes (2021)	Elucidate the benefits that gamified activities can bring to students with ADHD	Research has shown that the use of digital games can enhance the learning of students with ADHD, improving their executive functions and coping skills. These games help students to develop strategies that go beyond the game, helping them to cope with disabilities and improve their academic performance and social interactions. It is concluded that educators must understand the symptoms of ADHD, adapt modern methods and keep up to date in the digital age. Gamification benefits not only students with ADHD, but also their families, teachers and society in general, requiring knowledge, practice and innovation. Gamification is challenging, but doable.
Costa, Dias and Santos (2022)	To discuss the use of technology in learning with primary school children who have ADHD.	Research has shown that the use of digital games can enhance the learning of students with ADHD, improving their executive functions and coping skills. These games help students to develop strategies that go beyond the game, helping them to cope with disabilities and improve their academic performance and social interactions. It is concluded that educators must understand the symptoms of ADHD, adapt modern methods and keep up to date in the digital age. Gamification benefits not only students with ADHD, but also their families, teachers and society in general, requiring knowledge, practice and innovation. Gamification is challenging, but doable.
Pimenta, Duarte and Baranauskas (2022)	Investigating the use of the Aquarela Virtual system, a remote socio-active system, used in the context of a pre-school workshop, which includes a child diagnosed with ADHD.	The activity with the "Virtual Watercolor" system allowed the children to understand remote interactions with their peers using computers. In addition, they were able to explore elements of music and tell stories with different concrete materials, which also contributed to the teachers' work on expressing emotions.

Costa et al. (2021)	To analyze how ICCs are being used in the treatment of children with ADHD	It has been observed that different types of electronic devices have been used to treat children with ADHD, using interactions with interactive digital games. These interactions played a significant role, contributing to improvements in attention, social skills, behavior and the reorganization of brain functions. In addition, the use of this technology resulted in improvements in the children's attention span and behavioral control, which had a positive impact on their family and social relationships.
Gonçalves and Ferreira (2021)	To analyze some inclusive educational practices that permeate cyberculture aimed at students with SEN (Special Educational Needs), with an emphasis on students with ADHD (Attention Deficit Hyperactivity Disorder) who attend the final years of primary school.	The importance of digital literacy and inclusive literacy in teaching and learning was observed, especially for individuals with Special Educational Needs (SEN), such as ADHD, during Emergency Remote Learning. It shows that multimodal supports can be used to transform these students' relationship with reading and writing. It also emphasizes that it is the responsibility of the school, teachers, family and society to create the conditions for students with SEN to interact in any educational mode, respecting their differences. It also emphasizes that educators can no longer ignore the need to integrate students with SEN into the virtual environment, and that Digital Information and Communication Technologies (DICTs) offer important opportunities for the training of digital readers and the inclusion of these students.
Borges (2023)	To analyze some inclusive educational practices that permeate cyberculture aimed at students with SEN (Special Educational Needs), with an emphasis on students with ADHD (Attention Deficit Hyperactivity Disorder).	It was noted that these technologies can have a significant influence when combined with ongoing teacher training and inclusion in schools, considerably improving the teaching-learning process and assessment strategies.

Source: Research data (2023).

Based on the systematic review, it can be seen that the use of technology, in particular digital games and educational software, plays a significant role in supporting the teaching and learning process of children with ADHD. This research identifies the importance of modern and dynamic approaches to engaging students, improving their academic performance and coping skills.

Lima, Brandão and Ferreira (2022) emphasize that the use of educational software represents a significant advance in the learning process of students with ADHD. By incorporating educational games, teachers have at their disposal a highly effective tool for engaging students in a modern and dynamic way. This innovative approach has the power to capture students' attention in an exceptional way, creating a more attractive teaching environment and, as a result, promoting a notable increase in their school performance.

In addition, the survey highlights that teachers are already familiar with the use of some technological tools, such as computers and mobile phones, in their educational practices. This established technological base facilitates the incorporation of other free educational technologies, such as the games Kahoot, Duolingo, Perguntados, CodyCross, Voo Educativo, Mapa do Brasil, Mestre da Tabuada, Coleta Seletiva and Sistema Solar. The inclusion of these diverse tools makes lessons even more attractive and engaging, creating a favorable environment for the effective absorption of the content taught in the classroom.

This holistic approach, which combines the proven effectiveness of educational software with the accessibility of free technologies, highlights the importance of an innovative technological approach to teaching students with ADHD. It not only improves the academic performance of these students, but also offers educators a range of powerful tools to personalize and optimize the teaching-learning process, meeting the specific needs of these students more effectively. As a result, these students' potential for success is maximized, promoting a more inclusive and adaptive education.

In line with these prerogatives, Mendes (2021) emphasizes that the use of digital games in education can effectively improve the learning of students with ADHD. These games play a crucial role in developing students' executive functions, including skills such as attention control, planning and organization. In addition, digital games

provide an ideal platform for improving these students' coping skills, allowing them to develop effective strategies not only in-game, but also in real-life situations.

Mendes' research (2021) emphasizes that the benefits of gamification go beyond the educational context, positively impacting not only students with ADHD, but also their families, teachers and society in general. For this approach to be effective, educators must acquire a deep understanding of the symptoms of ADHD, adapt modern pedagogical methods and keep up to date with the digital age. Gamification represents a challenge, but it is a feasible and highly beneficial approach when implemented with knowledge, practice and innovation.

The effectiveness of digital games in the inclusion of children with ADHD is emphasized by Costa, Dias and Santos (2022), who point out that the inclusion of these children in the classroom can be effective in practice, especially when using technology-based approaches. Digital games have the ability to arouse children's natural curiosity, which in turn helps to control symptoms characteristic of ADHD, such as hyperactivity and restlessness. In addition, these games provide an interactive learning environment that allows children to complete tasks more effectively, thus promoting the development of essential academic skills.

The research by Costa, Dias and Santos (2022) emphasizes that technology plays an increasingly significant role in education, bringing students closer to the digital reality and empowering them with valuable technological skills for today's world. However, for this approach to be effective and inclusive, equal access to digital equipment and the internet is crucial. This requires investment through public policies that ensure that all children, regardless of their socio-economic situation, have access to the tools they need to make the most of the benefits of educational technology.

The authors Pimenta, Duarte and Baranauskas (2022) explore remote interaction through technologies such as the "Aquarela Virtual" system and its positive impact on the emotional expression and learning of children with ADHD. The system provided the children with a unique experience, allowing them to understand the complexities of remote interactions with their peers, while using computers as a learning tool.

One of the contributions of the authors' studies was the children's ability to explore elements of music and storytelling with different concrete materials, using the "Virtual Watercolor" system. This approach not only enriched the learning process, but also played a crucial role in developing the children's emotional expression skills. The teachers involved in the study noticed notable improvements in the children's ability to express their emotions effectively.

In addition, the study revealed that the "Aquarela Virtual" system played an important role in supporting the learning of children with Attention Deficit Hyperactivity Disorder (ADHD). The system's interactive and engaging interface helped these children maintain focus and concentration, which can often be challenging for them. This resulted in an increase in the children's active participation in learning activities and contributed to a more inclusive and collaborative classroom environment.

Costa et al. (2021) complement the discussion on the use of technologies in the treatment of children with Attention Deficit Hyperactivity Disorder (ADHD), highlighting the use of brain-computer interfaces (BCIs) and interactive digital games as effective tools for improving attention, social skills and behavior in these children.

The study by Costa et al. (2021) corroborated the observation that various types of electronic devices have been used to treat children with ADHD. In this context, brain-computer interfaces (BCIs) have proved to be a particularly promising approach. These interfaces allowed children with ADHD to interact with technology in a direct and immersive way, which in turn stimulated attention and control over their own brain responses.

Interactive digital games played a crucial role in this process, as they provided an engaging and playful environment in which the children could practice and develop their attention skills, while the ICC technology monitored their brain responses in real time. This allowed for personalized adaptations to the games, making them more effective in training attention and behavioral control.

As a result, the use of these technologies resulted in significant improvements in the attention span and behavioral control of children with ADHD. These improvements were not restricted to the treatment environment, but had a positive impact on the children's family and social relationships. As ADHD symptoms were managed more effectively, family interactions became more harmonious and the children's social skills also strengthened, contributing to a better overall quality of life.

Taking into account the benefits that technology can bring to children with ADHD, Gonçalves and Ferreira (2021) strongly emphasize the critical importance of digital literacy and inclusive literacy in the remote education scenario, with a special focus on integrating students with Attention Deficit Hyperactivity Disorder (ADHD) into the virtual learning environment.

The context of Emergency Remote Learning revealed unique challenges and opportunities, and the authors emphasize that the inclusion of individuals with Special Educational Needs (SEN), such as those with ADHD, requires a holistic approach. The use of multimodal supports has proved crucial, fundamentally transforming these students' relationship with reading and writing. The combination of text, audio, video and other multimodal modalities can provide a more inclusive and effective learning experience, taking into account the diversity of learning styles and individual needs.

The authors also emphasize that the responsibility for promoting inclusion lies with the school, teachers, families and society in general. It is essential to create an environment that respects differences and allows students with SEN to participate fully in any educational modality. This requires appropriate adaptations and support to ensure that these students have equal opportunities.

So educators can no longer ignore the need to integrate students with SEN into the virtual environment. Digital Information and Communication Technologies (DICTs) offer valuable opportunities for the training of digital readers and the inclusion of these students. Educators must look for creative and effective ways to use DICTs to meet the specific needs of each student, providing them with the tools and support they need to succeed in remote learning.

From this perspective, the work of Borges (2023) offers an important perspective on how new technologies can have a significant and positive influence on the teaching-learning process of children with Attention Deficit Hyperactivity Disorder (ADHD). Furthermore, the author emphasizes that this influence is even more effective when combined with ongoing teacher training and the practice of school inclusion.

The integration of new technologies, such as digital devices and interactive educational applications, into the teaching environment provides a number of benefits for children with ADHD. These technologies can offer more engaging and adaptive learning approaches, helping to maintain students' interest and concentration. Educational games, interactive simulations and other digital tools can make curriculum content more accessible and attractive, making it easier to understand and retain knowledge.

However, Borges emphasizes that the success of this approach depends on the preparation of teachers. Ongoing training for educators is essential so that they can make the most of the new technologies and adapt their teaching practices according to the specific needs of their students with ADHD. This includes the ability to personalize the use of these technologies to meet students' individual needs, creating a truly inclusive learning environment.

School inclusion also plays a fundamental role in this context. Ensuring that children with ADHD have the opportunity to participate fully in the school environment, interacting with their peers and teachers, is essential for the success of the teaching-learning process. Technologies can be a valuable tool to support inclusion, allowing for adaptations and additional resources that meet the specific needs of each student.

IV. Conclusion

This systematic review has shown the positive and transformative impact of technology on the teaching and learning process of children with Attention Deficit Hyperactivity Disorder (ADHD). The studies covered in the review emphasize the importance of adopting modern and dynamic approaches that incorporate digital games, educational software and other technological tools as valuable resources in teaching children with ADHD.

Technological tools can be effective in improving academic performance, developing coping skills and promoting the inclusion of these students. Gamification, the use of brain-computer interfaces (BCIs), the use of educational software and the creation of innovative virtual learning environments offer exceptional opportunities to engage and motivate children, making the learning process more attractive and effective.

In addition, the studies emphasize the importance of ongoing teacher training and school inclusion to maximize the benefits of these technologies. Well-prepared teachers can personalize the use of technologies according to the individual needs of their students with ADHD, creating a truly inclusive learning environment. School inclusion also plays a crucial role in ensuring that all children have equal access and opportunities to participate fully in education.

Ultimately, the research highlights that combining technology with effective pedagogical approaches can have beneficial effects on the education of children with ADHD. This not only improves their academic prospects, but also gives children the skills and strategies they need to face challenges in everyday life.

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