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THE MAGIC OF NEURAL NETWORKS: INNOVATIONS IN EDUCATIONAL PROJECTS

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ABSTRACT

This study aimed to analyze the impact of neural networks in education, especially with regard to the personalization of teaching, digital inclusion and the relationship with the principles of education 4.0. The research was conducted through a literature review, considering relevant studies and publications on the use of neural networks in educational contexts. The advantages and challenges of implementing these technologies in teaching were analyzed, highlighting the adaptation of content and data analysis to promote more efficient and inclusive learning. The results indicated that neural networks can transform pedagogical practices, providing personalization of learning and continuous monitoring of student performance. In addition, it was evidenced that these technologies contribute to digital inclusion, especially for students with special needs. However, challenges such as the cost of implementation, the need for educator training, and resistance to technology still need to be overcome. The final considerations pointed out that, although the benefits are significant, investment in infrastructure and continuous training of teachers is necessary to ensure the success of these innovations. The research also suggests that future studies should be conducted to complement the findings, focusing on the practical application of neural networks in the educational setting.

Keywords: Neural Networks. Personalization of Teaching. Digital Inclusion. Education 4.0. Educational Technologies.

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INTRODUCTION

Artificial neural networks have stood out as one of the main technological innovations today in the field of artificial intelligence (AI). These networks, which simulate the functioning of the human brain, have proven effective in several sectors, including education. In the educational context, the use of neural networks can transform the way students learn, providing personalized and interactive learning environments. The possibilities for applying these technologies in educational projects are vast, from improving academic performance to creating adaptive teaching tools that meet the individual needs of each student. In addition, neural networks offer solutions to complex problems, such as analyzing large volumes of educational data, predicting performance, and even implementing intelligent tutoring systems.

The importance of the study of neural networks in educational projects is justified by the growing demand for innovation in the teaching-learning process. With the acceleration of the use of digital technologies in schools, AI-based tools have the potential to transform classroom dynamics, optimizing learning and providing new forms of interaction. Neural networks, when applied to the educational context, can contribute to the personalization of teaching, creating learning experiences that adjust to the needs and pace of each student. In addition, these technologies can contribute to digital inclusion by providing accessible tools for all students, regardless of their limitations. The use of neural networks in education, although still in the expansion phase, has shown promising results, which makes its study essential to understand how these innovations can be incorporated into the school environment.

The question that guides this research is: How can neural networks be integrated into educational projects, and what are their impacts on the teaching-learning process? This question seeks to investigate the feasibility of using neural networks in schools, observing both the benefits and the challenges that arise with the implementation of these technologies. The main objective of this research is to analyze the innovations brought by neural networks in educational projects, evaluating their impacts on the development of pedagogical practices and on the personalization of teaching.

The text is structured as follows: it begins with the presentation of the theoretical framework, addressing the fundamental concepts about neural networks and their applications in education. Then, three development topics are discussed, which analyze the teaching methodologies that can be enhanced by neural networks, the benefits of their

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implementation and the challenges faced in practice. The work also describes the methodology used for the research and presents the results achieved through a critical analysis of the literature on the subject. Finally, the final considerations are presented, which summarize the conclusions of the study and propose ways for the implementation of neural networks in educational projects.

THEORETICAL FRAMEWORK

The theoretical framework is structured in order to provide an understanding of artificial neural networks and applications in the educational context. First, the fundamental concepts of neural networks are addressed, including their principles and historical evolution, providing a theoretical basis. Then, the text explores the various applications of neural networks in education, highlighting their impact on the personalization of teaching, as well as concrete examples of educational systems that use this technology. In addition, emerging technological innovations and the challenges faced in the implementation of neural networks in educational projects are discussed. From this organization, the theoretical framework aims to provide the reader with a comprehensive view of the theme, grounding the analysis and the debates that follow in the research.

ARTIFICIAL INTELLIGENCE AND NEURAL NETWORKS IN TEACHING

The relationship between Artificial Intelligence (AI), machine learning, and neural networks has been discussed in the educational context, since these technologies play essential roles in the transformation of teaching-learning processes. According to Chagas and Lima (2019), AI can be defined as the ability of computer systems to perform tasks that, until then, required human intelligence, such as decision-making, pattern recognition, and predictions. This technology is linked to machine learning, a field that allows machines to learn from data, without being programmed to do so. Within this context, artificial neural networks, one of the main components of AI, emulate the functioning of the human brain, using layers of artificial neurons to process complex information, which has been fundamental to improve the capacity for analysis and prediction in educational systems (Pasini; Unopar; Silva, 2021).

The practical applications of AI and neural networks in learning environments have expanded, bringing new approaches to teaching and student assessment. According to Grando (2020), neural networks have been used to create personalized content

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recommendation systems, adjusting to the needs and performance of students, based on real-time interactions. This personalization allows for efficient learning, as it adapts the content to the specific difficulties of each student, promoting individualized learning. In addition, AI has been applied in the automation of administrative processes, such as assigning grades in assessments and monitoring student progress, which contributes to agile school management (Oliveira & Stringhini, 2020).

In addition to these applications, AI has been used in the creation of inclusive educational tools, as demonstrated in the study by Burato, Franco, Rezende, and Daniel (2023). According to the authors:

> Artificial Intelligence is widespread in the routine of Brazilians and studies of Artificial Neural Networks are sponsored for the computer simulation of the cognitive capacity of human beings. Associated with this, the sphere of Assistive Technology is a segment of science that aims to take advantage of technological developments to meet the needs of people with disabilities, with the hearing impaired public, which communicates through the Brazilian Sign Language, being one of those who lack numerous benefits that society promises to offer to everyone and that are worthy of any individual, such as studying in schools since childhood, helping with opportunities in the job market, in social interactions and, especially, in communication. Therefore, through the use of Artificial Intelligence, the objective of this work was to develop a computational algorithm, based on the methods of Recurrent Neural Networks and LSTM, which have memory cells, for recognition of sequential and moving signs of LIBRAS, presenting it in the form of an application compatible with any cell phone, for children to interact and learn the language from an early age in a natural way, promoting the educational, social and labor inclusion of hearing impaired people in Brazil (Burato; Franco, Rezende; Daniel; 2023, p. 2).

This example demonstrates how AI can be used to promote inclusion and accessibility in teaching, making learning democratic and efficient. To ensure the successful implementation of these technologies, Burato, Franco, Rezende, and Daniel (2023) highlight the importance of a structured process for the development of systems based on neural networks, as they describe:

> Knowing this, it was necessary to follow a sequence of eight processes, which were the analysis and definition of simple, childish and trivial signs in LIBRAS, the choice of Python as the programming language, the preparation of the programming environment, the coding using Image Processing and the TensorFlow library, the collection of data through a camera for the recording of the signals, the training of the LSTM Neural Network, and the validation of the results. An accuracy of more than 80% was achieved for all signs, ensuring optimal functioning of the system and making it possible to carry it forward as a LIBRAS learning application for thousands of people (Burato; Frank; Rezende; Daniel, 2023, p. 3).

Concrete examples of educational systems that use AI and neural networks abound, with several initiatives at different levels of education. An example highlighted by Veloso

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(2020) is the use of neural networks for the facial analysis of emotions in smart classrooms, allowing educators to identify, in real time, students' emotions during classes and adjust their pedagogical approaches as needed. In addition, the implementation of AI in educational platforms has shown a positive impact on the creation of dynamic and interactive learning environments, in which computational intelligence assists both in teaching and in supporting special needs, as demonstrated by Batista (2023) in his study on the use of AI in educational nanosatellites. Such examples indicate how neural networks can be integrated into the educational context, bringing innovation, personalization, and efficiency to the teaching-learning process.

TEACHING METHODOLOGIES BASED ON NEURAL NETWORKS

Teaching methodologies based on neural networks have shown great potential to modify traditional pedagogical practices, due to the ability to personalize teaching according to the needs and performance of each student. According to Pasini, Unopar, and Silva (2021), neural networks allow the creation of adaptive systems that analyze students' progress and adjust content dynamically, creating an individualized learning environment. This personalization can contribute to improving the quality of teaching, since it allows each student to follow a learning path appropriate to their pace and cognitive style, instead of following a homogeneous and standardized approach. Thus, the function of neural networks in this context is fundamental, as they are capable of transforming performance data into useful information for the continuous improvement of pedagogical practices (Grando, 2020).

In addition, the emergence of new hybrid and personalized teaching methodologies has been influenced by the use of neural networks, which allow the integration of different forms of learning, such as face-to-face and online. Chagas and Lima (2019) state that hybrid teaching, by incorporating neural network technologies, provides a fluid interaction between classroom activities and digital resources, allowing for integrated and continuous learning. In this model, neural networks are used to monitor student participation, their interactions with courseware, and their progress in real-time, adjusting content and methodology as needed. This type of approach aligns with the principles of personalized teaching, where the focus is not only on transmitting knowledge, but also on closely monitoring and guiding the student, based on analytical data obtained by neural networks (Oliveira & Stringhini, 2020).

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In the teaching-learning process, neural networks play a key role in providing an engaging and efficient educational experience. According to Batista (2023), they have the potential to transform the way students interact with content, as they are able to perform predictive analysis on student performance, offering personalized recommendations.

From this context, it is evident that neural networks not only help in the construction of interactive learning environments, but are also applied to promote accessibility and inclusion in teaching. This type of approach, by integrating technology and pedagogy, not only makes it easier to adapt teaching to the individual needs of students, but also expands educational possibilities for marginalized groups. In this way, the use of neural networks in teaching continues to consolidate itself as an essential tool for more accessible, dynamic, and personalized learning, preparing students for the challenges of an increasingly digital and complex world.

BENEFITS AND CHALLENGES OF INTEGRATING NEURAL NETWORKS IN EDUCATION

The integration of neural networks in education offers several significant benefits that can transform the teaching-learning process. One of the main benefits is the personalization of learning, which allows adapting content and methodologies to the individual needs of each student, promoting learning aligned with the cognitive styles of each student. Pasini, Unopar, and Silva (2021) highlight that personalization allows neural networks to adjust the difficulty level of activities and provide real-time feedback, which helps optimize student performance throughout the educational process. In addition, neural networks can contribute to digital inclusion by facilitating access to educational materials and personalized resources, especially for students with special needs, providing an accessible and equitable learning environment (Chagas & Lima, 2019). Another advantage is better tracking of student progress, as neural networks have the ability to analyze large volumes of data and generate reports on academic performance, allowing educators to make informed decisions about pedagogical interventions (Grando, 2020).

When considering the impacts of neural networks on education, Sucena; Silva; Faria (2018) emphasize the importance of applying these technologies to better understand students' cognitive performance and support the development of educational policies. According to the authors:

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> to develop a mathematical model, implemented in a computational application, supported by Integral-Fuzzy and Artificial Neural Networks (ANN) techniques, to process data from research in the field of psychology. Significant information should be generated about the collective and individual cognitive performance of the Production Engineering course, allowing the enhancement of the positive educational policies in operation, mitigating negative ones and suggesting some that can optimize the student's potential, according to their collective and individual characteristics (Sucena; Silva; Faria, 2018, p. 122).

This analysis reinforces that neural networks play an essential role in education by transforming complex data into strategic information that helps both students and educators. However, the implementation of this technology also faces significant challenges that need to be overcome to ensure its effectiveness. One of the main obstacles is the cost of implementation, since the adoption of this technology requires significant investments in technological infrastructure, such as servers and specialized software, in addition to the maintenance of these systems (Oliveira & Stringhini, 2020, p. 64). In addition, the training of educators is essential for them to be able to use tools based on neural networks. The lack of adequate training can limit the full use of the potential of these technologies, which can result in a reduced impact on the educational process (Batista, 2023).

Another challenge is the resistance to technology on the part of teachers, students, and even school administrators, who often feel insecure or uncomfortable with the adoption of new digital tools. Resistance can be strong in traditional educational settings, where conventional pedagogical practices still prevail.

By critically analyzing the benefits and challenges of integrating neural networks in education, it is possible to observe that, although the benefits are substantial, successful implementation depends on overcoming the challenges mentioned. Personalization of learning and digital inclusion, for example, can be transformative, but only if the necessary resources are made available and educators are prepared to use technology. Resistance to technology also needs to be addressed with strategies of awareness and continuous training, ensuring that all those involved in the educational process understand the advantages of using neural networks and feel comfortable incorporating them into their pedagogical daily life. Thus, it is essential to balance the benefits offered by this technology with overcoming the challenges so that the integration of neural networks in teaching is effective (Sucena; Silva; Faria, 2018).

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METHODOLOGY

The following excerpt was inspired by Santana, Narciso and Fernandes (2025), who address the importance of scientific methodologies in conducting academic research, highlighting the relevance of the qualitative and bibliographic approach for the analysis of educational phenomena. Based on these principles, the research adopted a qualitative approach, of the bibliographic type, allowing an investigation of the literature on the use of neural networks in educational projects.

The research was conducted based on a review of academic sources, based on databases such as *Google Scholar, Scopus*, and other platforms for accessing scientific publications. Primary data collection, such as interviews or questionnaires, was not carried out, since the focus was on the theoretical analysis of texts already published. As instruments for data collection, selected bibliographic references were used, which were analyzed for their content, relevance and relationship with the proposed theme. The technique used was the critical reading and synthesis of the information extracted from the selected works, aiming to identify the contributions of each author to the understanding of the central theme of the research. The analysis involved the comparison of theoretical and practical approaches, as well as a critical evaluation of the results presented in the studies consulted.

The following table presents an organization of the main bibliographic references consulted for the construction of this study. It synthesizes the essential information about the reviewed works, such as author(s), title, year of publication and type of work, allowing an objective visualization of the sources that support the research.

Table 1: Main bibliographic references consulted

Author(s)	Conforming title published	Year	Type of Work
SUCENA, M. P.; DA SILVA, D. C. C.; DE FARIA, A. F.	Neuropsychological-Fuzzy model to support the analysis of educational procedures in Production Engineering.	2018	Revista de Ensino de Engenharia, v. 37, n. 1, p. 117-134
CHAGAS, L. B. da C.; LIMA, J. R	A predictive model in the diagnosis of programming learning.	2019	Brazilian Journal of Development, v. 5, n. 4, p. 216-235
SILVA, E.; CRUZ, J.	Educational data mining: use of artificial neural networks in the prediction of the student's academic profile – IFAL Campus Maragogi.	2019	In: XIX Escola Regional de Computação Bahia – Alagoas – Sergipe (ERBASE), Salvador: SBC

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GRANDO, A.	Facial analysis of emotions using neural networks in the context of an intelligent classroom.	2020	Dissertation (Master's Degree) – University of Caxias do Sul (UCS), Caxias do Sul
OLIVEIRA, T.; STRINGHINI, D.	Artificial Neural Network for Grading Technical Reports in a Context of Peer Evaluations and Rubrics.	2020	Journal of New Technologies in Education, v. 18, n. 2, p. 56-75
VELOSO, J. H. C.	Design of an ADC based on a Hopfield neural network.	2020	Dissertation (Master's Degree) – Universidade Nova de Lisboa (UNL), Lisbon
PASINI, R. R. D. E. M.; UNOPAR, A. G.; SILVA, F. D. E. A. E.	Educational software for teaching artificial neural networks.	2021	Thesis (Doctorate) – PGSSCogna University, Curitiba
BATISTA, L. S.	Electrical system for nanosatellites: tracking of maximum power through artificial neural networks.	2023	Dissertation (Master's Degree) – Federal University of Maranhão (UFMA), São Luís
BURATO, A.; FRANCO, I. F. B.; REZENDE, K. H. L.; DANIEL, P. H. R.	Children's didactic device for learning Brazilian Sign Language with artificial neural networks.	2023	Final Paper (Undergraduate) – Instituto Mauá de Tecnologia, São Caetano do Sul

Source: The authors.

After inserting the table, it can be observed that it offers an overview of the sources used, evidencing the diversity of types of publications that were considered for the analysis. These references were selected according to their relevance and contribution to the understanding of the use of neural networks in education, constituting the theoretical basis that supports the discussions and results presented throughout the research.

RESULTS AND DISCUSSION

The Word Cloud presented below reflects the frequent and significant terms that have emerged from the frame of reference, which will be discussed in the following topics, results, and analyses. Through this visual representation, it is possible to clearly observe the central concepts that guide the research, such as 'neural networks', 'artificial intelligence', 'personalization', 'education 4.0', 'digital inclusion', and 'teaching'. These terms highlight the key areas that will be explored throughout the work, providing a concise overview of the relevant topics for the analysis and discussion of the impact of neural networks in education.

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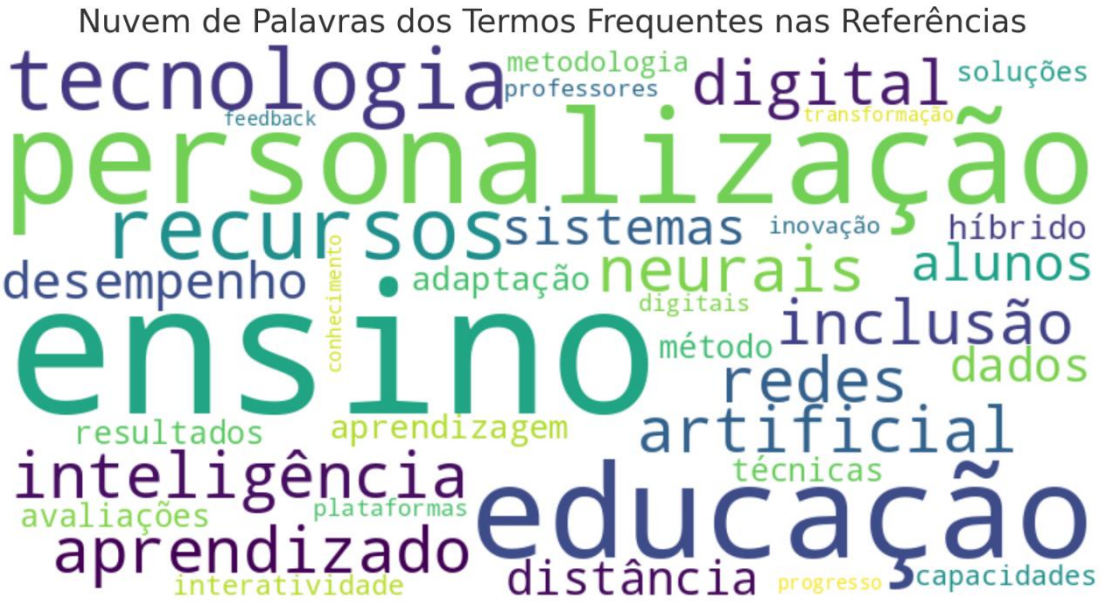
Image 1- Word Cloud



Source: The authors.

These terms reflect key areas of research focus, such as the personalization of teaching and the advances provided by neural networks in the educational process. From this word cloud, the reader can obtain an overview of the themes that will be deepened in the subsequent sections, allowing a better understanding of the objectives and implications of the application of advanced technologies in the educational context.

RESULTS OF THE APPLICATION OF NEURAL NETWORKS IN TEACHING

The literature on the application of neural networks in teaching points to positive results in several areas, showing how this technology has the potential to transform the educational environment. Chagas and Lima (2019) highlight that neural networks have been used to personalize learning, which results in an improvement in student performance, by allowing content to be adjusted according to the individual needs of each student. In addition, neural networks are able to analyze students' progress in real-time, offering continuous *feedback* that contributes to the constant improvement of learning. This type of dynamic adaptation provides an efficient and inclusive teaching environment, catering to a diverse range of learning styles and pedagogical needs (Oliveira & Stringhini, 2020).

Concrete examples of success in the application of neural networks at different levels of education reinforce these positive results. Grando (2020) presents the case of schools that implemented neural network-based systems to analyze students' emotional

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behavior during classes, allowing educators to adjust their pedagogical approaches efficiently. This type of application has shown effectiveness in promoting an interactive and responsive learning environment, which contributes to student engagement and the reduction of behavioral problems. In addition, the use of neural networks in distance learning platforms has proven to be advantageous, as it allows for accurate monitoring of students' progress, adjusting content in a personalized way, and thus increasing the effectiveness of *online teaching* (Batista, 2023).

Another example of success in the use of neural networks can be found in higher education, where systems based on this technology have been applied to improve the evaluation and monitoring of students in courses in various areas. Pasini, Unopar, and Silva (2021) report on the use of neural networks in engineering courses to predict students' academic performance based on their assessment history and engagement in course activities. This type of application has allowed educators to intervene, offering specific support to students who have difficulties in certain areas. Such results demonstrate the ability of neural networks to promote adapted teaching, benefiting both students and educators at different levels and educational contexts.

IMPACTS ON COGNITIVE AND EDUCATIONAL DEVELOPMENT

The impacts of neural networks on cognitive and educational development have been discussed in the literature, with emphasis on the benefits that this technology offers to student performance. Chagas and Lima (2019) report that neural networks have been successfully applied to monitor student progress, allowing pedagogical interventions. In a case study carried out in an educational institution, it was observed that the application of neural networks helped to identify the specific difficulties of each student, providing personalization in the teaching process. This has enabled educators to adjust content and pedagogical strategies according to the individual needs of students, resulting in significant improvements in academic performance and student motivation.

In addition, neural networks have played a key role in the personalization of teaching, which has direct implications for students' cognitive evolution. Pasini, Unopar, and Silva (2021) point out that, through the use of this technology, it is possible to create a dynamic learning environment, in which students receive content in the format and depth that best meets their cognitive needs. This type of personalization not only makes it easier to understand the concepts but also allows students to advance at their own pace,

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promoting efficient and less stressful learning. Personalization, therefore, is seen as an essential factor to optimize cognitive development, as it allows the student to focus on their areas of difficulty, overcoming them gradually.

With regard to assessment methods, neural networks have demonstrated effectiveness in providing an accurate approach adapted to the reality of each student. According to Grando (2020), neural networks can be used to evaluate student performance continuously, without the need for traditional assessments based on single tests. This continuous assessment methodology allows educators to gain insight into student progress, identifying not only academic performance but also aspects such as engagement and participation in the proposed activities. The use of neural networks, therefore, contributes to personalized monitoring, which reflects on the cognitive development of students, as it allows quick adjustments in pedagogical approaches as the results are analyzed. Thus, the integration of neural networks into assessment methods offers a holistic view of learning and can promote significant improvements in both student performance and their educational trajectories.

CONSIDERATIONS ON DIGITAL INCLUSION AND EDUCATION 4.0

Neural networks play a key role in promoting digital inclusion, especially in educational contexts that seek to cater to the diversity of learners, including those with special needs. According to Batista (2023, p. 19), neural networks can be used to create adaptive teaching systems, which adjust pedagogical materials and methods to the specific difficulties of students, facilitating access to learning in an equitable way. This personalization contributes to the inclusion of students with different learning paces and styles, ensuring that each student has the same opportunities for educational development, regardless of their limitations or disabilities. In addition, neural networks help in the creation of accessible educational tools, such as software that interprets sign language signs or that offers text adaptations for students with visual impairments, expanding the possibilities of digital inclusion in schools (Chagas; Lima, 2019).

The relationship between neural networks and the principles of education 4.0 is intrinsic, since this technology is aligned with the objectives of this new educational approach. Pasini, Unopar, and Silva (2021) highlight that education 4.0 emphasizes the personalization of learning, the use of digital technologies, and the creation of dynamic and collaborative learning environments, characteristics that are compatible with neural

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networks. These networks, by allowing the analysis of large volumes of data on the performance and needs of students, contribute to the construction of an adaptive education, in which the content is adjusted according to the progress of each student. Thus, neural networks not only enable the personalization of teaching, but also promote efficient and inclusive education, which is one of the pillars of education 4.0. Grando (2020) also emphasizes that, by integrating neural networks into educational processes, it is possible to create flexible learning systems, in which the student has the autonomy to follow their own learning path, with the support of technologies that adjust to their needs. In this way, neural networks are an essential element in the implementation of the principles of education 4.0, helping to transform the way teaching is conducted and how students interact with educational content and technologies.

FINAL CONSIDERATIONS

The final considerations of this study aim to highlight the main findings of the research on the use of neural networks in education, especially in relation to the personalization of teaching, digital inclusion and the relationship with the principles of education 4.0. Throughout the analysis, it was possible to observe that neural networks, when applied correctly, play a significant role in the transformation of traditional pedagogical methods. The personalization of teaching, through the adaptation of content and assessments, proved to be one of the main benefits of this technology, allowing learning to be adjusted according to the needs and individual rhythms of students. This approach contributes to teaching, catering to a greater diversity of learning styles and promoting digital inclusion, as it facilitates access for all students, including those with disabilities or learning difficulties.

The relationship between neural networks and education 4.0 was also clear, since the use of these technologies is aligned with the principles of this new educational approach, such as personalized learning, the use of interactive digital tools, and the promotion of dynamic educational environments. The integration of neural networks in education systems, by allowing the collection and analysis of real-time data on student performance, helps in the implementation of innovative methodologies that better meet the needs of each student. In addition, neural networks are an important resource for the development of solutions that make the teaching process efficient and inclusive, especially in an increasingly digitized educational scenario.

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However, it is important to emphasize that, despite the benefits identified, the research also points to the need to face some challenges for the full integration of neural networks in the educational environment. The cost of implementation, the need for educator training, and resistance to technology, both by teachers and students, are issues that need to be addressed to ensure the success of this technology. The continuous training of teachers and school managers, as well as investment in infrastructure, are fundamental aspects to enable the adoption of neural networks on a large scale in teaching. Thus, for the use of neural networks to become accessible, a joint effort is needed between educational institutions, governments, and academic communities.

Regarding the contributions of the study, this work offers an understanding of the function of neural networks in the educational context, evidencing their capabilities and limitations. The research contributes to the understanding of how these technologies can be strategically applied to improve teaching and learning, as well as to increase digital inclusion. In addition, the analysis allows us to understand the relationship between neural networks and the principles of education 4.0, showing how digital tools can be integrated in an innovative way in pedagogical processes. However, the findings of this study are limited by the bibliographic nature of the research, which was based only on the analysis of secondary sources.

Finally, it is evident that the area of study on neural networks and education still lacks empirical research that can complement and validate the findings of this review. Future studies involving the practical application of neural networks in real educational settings can provide an understanding of the impacts of this technology, identifying best practices, specific challenges, and efficient implementation strategies. In addition, investigations that explore the perception of educators and students about the use of these technologies can contribute to the development of appropriate teaching methodologies adapted to the real needs of the educational context. Thus, there is still a vast field of research that can expand knowledge about the use of neural networks in education, complementing the results presented in this study and offering new perspectives for the future of digital education.

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