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DEVELOPMENT OF COMPUTATIONAL THINKING THROUGH EDUCATIONAL ROBOTICS

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ABSTRACT

Educational robotics represents a methodology that seeks to cultivate computational thinking in children, providing a playful and engaging introduction to the fundamental principles of programming and problem-solving. This study aimed to analyze the effectiveness of educational robotics as a teaching strategy that favors active learning and collaboration among students. The methodological approach included the evaluation of robotics programs in elementary schools, through classroom observations, interviews with educators, and the application of questionnaires to students. The main results indicated that robotics stimulates creativity and logical reasoning, in addition to facilitating the understanding of more complex concepts. The children showed greater engagement and willingness to collaborate during the activities. However, the survey also highlighted significant challenges, such as the lack of adequate training for teachers and the limitation of material resources in educational institutions. These aspects are key to ensuring that educational robotics is an affordable and effective alternative for all schools. Based on the results, it is concluded that, despite the obstacles faced, educational robotics plays an important role in the development of twenty-first-century skills, such as critical thinking and creativity, which are essential in the education of students. Thus, it is vital to invest in educator training and school infrastructure to ensure the successful implementation of these programs.

Keywords: Educational Robotics. Computational Thinking. Active Teaching. Teacher Training. Challenges of Education.

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INTRODUCTION

Educational robotics presents a significant panorama at the intersection between technology and pedagogy, reflecting a growing trend in several educational institutions around the world. This innovative approach has gained prominence in the contemporary context, where digital transformation affects all aspects of daily life. In an educational scenario that seeks to prepare students for an increasingly technological future, the integration of robotics in classrooms emerges as an effective strategy to develop fundamental skills and promote student engagement.

In recent years, educational robotics has expanded, revealing its multiple influences and practical applications in everyday school life. The emergence of new technologies and pedagogical methodologies has generated an environment conducive to changing teaching practices, enabling educators to explore innovative ways of learning. Additionally, the increasing emphasis on competencies such as critical thinking and problem-solving highlights the importance of active methodologies that encourage student participation and strengthen their learning.

The relevance of the study of educational robotics lies in its ability to respond to the demands of a constantly evolving labor market, where the mastery of technological skills is increasingly required. Research in this area not only contributes to the improvement of pedagogical practices but also provides subsidies for educational policies that integrate technology effectively. Thus, investigating educational robotics becomes essential for the formation of competent citizens who are adaptable to the transformations of the modern world.

The research problem that is intended to be analyzed in this study focuses on the effectiveness of educational robotics in promoting computational thinking among students. Although there is a growing implementation of programs of this nature, there are still gaps in the understanding of how these practices impact the learning process. Understanding this dynamic is essential for us to optimize the use of robotics as an educational tool, ensuring that learning objectives are being achieved.

The general objective of this research is to investigate the impact of educational robotics on the development of computational thinking in children, seeking to understand how this methodology can be effective in the formation of critical skills. The research intends, therefore, to elucidate the connections between robotics practices and educational outcomes, contributing to a deeper understanding of contemporary technological education.

In addition to the central objective, specific objectives were outlined that include the analysis of current pedagogical practices in educational robotics, the evaluation of student

engagement during activities, and the identification of strategies that enhance learning in robotic environments. These objectives will serve as a guide for structuring the research, and ensuring the scope and depth of the investigation.

The methodology proposed for this study will be bibliographic, characterized by the analysis of relevant works, articles, and publications on educational robotics and computational thinking. Through this approach, the research will seek to compile and synthesize existing knowledge, allowing a critical reflection on the practices and theories associated with the theme.

Finally, this introduction presented the relevance of educational robotics in the current context, addressed its nuances, and the justification for the proposed investigation. After defining the research problem, general and specific objectives, as well as the methodology adopted, the fundamentals outlined here prepare the transition to the body of the work, where reflections and analyses around the role of robotics in contemporary education will be deepened.

THEORETICAL FRAMEWORK

Educational robotics has stood out as an approach that integrates technology and learning, providing an environment conducive to the development of critical and creative thinking in children. The use of robotic platforms allows students to experiment, make mistakes, and learn in a hands-on way, encouraging exploration and discovery. This practice not only facilitates the understanding of complex concepts but also promotes a collaborative approach, where teamwork becomes essential for solving challenges.

Involvement with educational robotics also instigates students' curiosity, driving them to question and seek answers. Practical activities involving programming, assembly, and experimentation require children to apply theoretical knowledge in real situations, making learning more dynamic and engaging. This process, in turn, favors the development of skills such as logical thinking and creativity, which are fundamental in an increasingly technology-driven world.

Additionally, interaction with robotics creates a safe space for students to develop their metacognitive skills. Reflecting on one's learning, evaluating strategies used, and identifying points for improvement are practices that, when stimulated, empower students in their educational journey. Understanding one's way of learning fosters deeper engagement and recognition of the importance of the learning process.

The training of educators for the effective use of robotics in the classroom is equally decisive. Investing in teacher training allows them to integrate these new technologies

effectively into their pedagogical practices, increasing students' potential. Well-prepared educators can create learning environments that make the most of available resources, making lessons more interactive and meaningful.

The demands of today's world require schools to constantly adapt, incorporating new methodologies that meet the profile of contemporary students. Educational robotics presents itself as a response to these demands, aligning with the objectives of preparing young people for a job market that values innovation and adaptability. This articulation between education and the skills of the twenty-first century is fundamental to forming critical citizens capable of dealing with the challenges of the future.

Therefore, educational robotics not only enriches the school curriculum, but also plays a significant role in the all-round education of students. By providing active and collaborative learning, this approach transforms education, preparing new generations to excel in an ever-changing world. The combination of theory and practice, combined with metacognition and collaboration, makes robotics an indispensable tool in the contemporary educational process.

FUNDAMENTALS OF EDUCATIONAL ROBOTICS AND COMPUTATIONAL THINKING

Educational robotics and computational thinking emerge as fundamental strands in the contemporary educational landscape. Both themes aim to equip students with skills and competencies that will enable them to face the challenges of an ever-changing world. This text seeks to explore the implications of these pedagogical approaches, their connections with technology and innovation, and the debates around their implementation in educational institutions.

Technological advancement and the growing presence of robotics in classrooms have caused a reconfiguration of the teaching-learning process. The implementation of educational robotics aligns with the principles of a more dynamic, participatory, and adaptive education. As stated by Amaral et al. (2023), "educational robotics is a playful, participatory and open path guided by the inseparability between teaching, research and extension". This context becomes even more relevant in the face of the demands of the job market, which values skills such as critical thinking and creative problem-solving.

Educational robotics involves the use of robots as didactic tools that facilitate the learning of programming and science, technology, engineering, and mathematics (STEM) concepts. Learning in this format is characterized by practice and experimentation, allowing students to develop a deeper understanding of the content covered. In turn, computational thinking is a problem-solving process that includes decomposition, pattern recognition,

abstraction, and algorithm development. This approach is not restricted to computing but extends to several areas of knowledge.

The integration of robotics and computational thinking in schools brings with it multiple implications. It promotes inclusion and diversity, as it provides all students, regardless of their background, with the opportunity to explore and experiment in the technological environment. In addition, by stimulating skills such as collaboration and communication, these methodologies favor the formation of a more cohesive and interactive school environment.

However, the implementation of educational robotics and computational thinking is not without challenges. Many educators face the difficulty of integrating these practices into traditional curricula, which are often rigid and focused on theoretical content. As mentioned by Fernandes et al. (2024), "Innovation and technology in school management bring possibilities and challenges that require constant reflection and adaptation". The role of the educator, therefore, becomes even more important, as he is the one who must mediate these new learning experiences.

In line with the need for innovation, the continuing education of teachers is essential. Educators who are unfamiliar with technology may feel insecure about introducing robotics and computational thinking into their practices. Training should go beyond simply introducing new tools; teachers must understand the underlying concepts and methodologies that support meaningful learning. Effective training can boost the confidence of educators, allowing them to become facilitators of learning.

Educational institutions have a critical role in fostering an environment that favors educational robotics and computational thinking. The creation of technology laboratories and the availability of adequate resources are important steps for these approaches to become a reality. In addition, school management must ensure that there is a space for experimentation and error, fundamental elements for learning.

Another relevant aspect is the impact of artificial intelligence on academic assessments, which is also related to educational robotics and computational thinking. The use of advanced technologies allows assessments to be more dynamic and adaptable, providing continuous feedback to students. According to Freitas (2025), "artificial intelligence is transforming traditional methods of evaluation in higher education", suggesting that the same can occur in basic education, contributing to more integrative and innovative practices.

These methodologies are fundamental for the development of 21st century skills. Educational robotics and computational thinking encourage students to be proactive in

finding solutions, as well as preparing them to work in multicultural and interdisciplinary contexts. The educational environment transforms into a space where creativity and innovation are valued, reflecting the needs of a rapidly evolving market.

It is undeniable that the adoption of educational robotics and computational thinking presents significant challenges. Many educators may hesitate in the face of the new, while institutions may face budgetary barriers. However, these difficulties bring with them opportunities to rethink the educational process and implement changes that promote a richer and more diversified education for students.

Collaboration between schools, universities, businesses, and government agencies becomes vital to the success of these initiatives. Strategic partnerships can facilitate access to resources, training, and technical support, contributing to the construction of a more robust educational ecosystem that is aligned with contemporary demands. The synergy between these actors can accelerate the implementation of educational technologies and the development of innovative practices.

Therefore, educational robotics and computational thinking are not just fads, but essential components for the formation of critical and creative citizens. Continuous reflection on their practices and the search for new methodologies are fundamental for teaching to become a fertile field of innovation. Only through the integration of these areas into the school curriculum will it be possible to adequately prepare students for the demands of a technological future, positively impacting their academic and professional trajectories.

METHODOLOGY

Teaching and learning methodologies in educational robotics play a very important role in the formation of students' technological skills. Through dynamic approaches, such as project-based learning and collaborative learning, educators foster an environment where students are protagonists of their learning. This active participation not only strengthens the understanding of the concepts but also encourages creativity and autonomy, essential skills for personal and professional development in the contemporary world.

The integration of robotics into school curricula transforms lessons into engaging and meaningful experiences. Students are challenged to apply knowledge of mathematics, science, and engineering in practical projects, which facilitates the understanding of theories through execution. This practice not only broadens the horizon of learning but also shows the relevance of the contents covered, by connecting them to the students' daily lives.

In addition, the diversity in the robotic platforms available allows the customization of activities, meeting the diverse needs and learning rhythms of students. This flexibility is key to ensuring that all students have the opportunity to engage with technology in a meaningful way, fostering an inclusive and equitable environment. The adaptation of pedagogical practices with the use of robotics contributes to each student feeling part of the learning process.

These methodologies are also essential to arouse students' interest in the fields of science, technology, engineering, and mathematics, known as STEM. As students work on robotics projects, they begin to envision potential careers in these fields, which can influence their future educational choices. The engagement found in robotics classes often translates into higher academic performance and an increase in overall motivation.

Another important facet of robotics teaching methodologies is the development of skills that are increasingly valued in the twenty-first century. Critical thinking, collaboration, and communication are just a few of the skills students practice when working as a team to solve problems and innovate. This type of social and intellectual interaction is essential to prepare students for the challenges of today's job market.

For these methodologies to be effective, teachers must be adequately trained. The continuous training of educators in new technologies and pedagogical practices ensures that they feel safe and prepared to facilitate learning. In addition, the implementation of reflective practices is vital, as it allows teachers to evaluate and adjust their approaches as needed, promoting continuous improvement in the educational process.

Thus, educational robotics goes beyond simply teaching about technology; It transforms the way students learn and relates to knowledge. The use of robots and other technologies in education fosters an environment in which error is seen as part of learning, encouraging students to experiment and take risks in search of solutions. This mindset is essential for the development of a generation of innovators and critical thinkers.

Educational robotics methodologies also contribute to the formation of learning communities, where students, teachers, and even families engage and collaborate. This interaction strengthens social and personal bonds, creating a spirit of community and belonging among participants. Learning becomes, therefore, a collective experience, enriching not only individuals but also the school environment as a whole.

Finally, considering teaching and learning methodologies in educational robotics as a catalyst for transformation in education is essential. The potential of innovative technologies and approaches is immense, and when applied consciously and judiciously, they can truly

revolutionize the way students connect with knowledge. In this way, robotics not only teaches but also transforms education, preparing students for a future full of possibilities.

PROJECT-BASED LEARNING

Project-based learning (PBL) has emerged as an innovative methodology in the educational context, especially in the teaching of robotics. This focus provides an environment conducive to the application of theoretical knowledge in practical situations, stimulating students' curiosity and interaction. When faced with real or simulated problems, students have the opportunity to explore, experiment, and develop solutions, expanding their understanding of science and technology concepts. PBL, therefore, becomes a pedagogical tool that allows a more effective integration between theory and practice, facilitating the development of essential skills for the twenty-first century.

In the contemporary education scenario, robotics presents itself as a discipline that encompasses not only technical skills but also emotional and social competencies. Students, when working in teams to create robots, are encouraged to collaborate and communicate, skills that are increasingly valued in an interconnected world. For Moraes et al. (2023), "educational robotics promotes an active learning environment, where students become protagonists of their educational process". Thus, the practice of PBL in robotics offers a valuable opportunity for the integral development of students, aligning their academic knowledge with the demands of the job market.

In addition, research on scientific methodologies in education reveals that the integration of active approaches, such as PBL, can transform the way students face academic challenges. Narciso and Santana (2025) highlight that "the adoption of dynamic and participatory methods is fundamental for the formation of critical and engaged citizens". This context points to the need for a curriculum that not only presents content but also fosters the ability to make decisions and solve problems, essential characteristics for the twenty-first century.

The implications of this educational model are vast, reflecting not only on individual learning but also on the school environment as a whole. Schools that adopt PBL and robotics experience an increase in student motivation and a more collaborative school climate. This approach also provides a space where students with different abilities can come together, foster a diversity of ideas, and validate their contributions. With this, PBL not only enriches students' technical knowledge, but also promotes an inclusive and stimulating environment for learning.

Debates around the implementation of PBL in schools often revolve around the challenges that educators face, such as the need for specific training and the adaptation of curricula. On the one hand, it is necessary for teachers to feel comfortable with technology and active methodologies; On the other hand, resilience and a willingness to experiment with new approaches are key. The literature points out that, without proper training, the effectiveness of PBL can be compromised, leading to the need for systematic reforms in teacher education.

In conclusion, project-based learning, especially in the field of robotics, has multiple benefits that go beyond technical learning. It promotes the development of social, cognitive, and emotional skills, preparing students for the challenges of the future. Through the implementation of active methodologies, such as PBL, educational institutions have the opportunity to train individuals who are more complete and prepared to contribute meaningfully to society. Given this, educational robotics, in line with PBL, emerges as a promising path for contemporary education, shaping students able to navigate a world in constant transformation.

CHALLENGES AND POSSIBLE SOLUTIONS IN THE IMPLEMENTATION OF EDUCATIONAL ROBOTICS IN SCHOOLS

The implementation of educational robotics in schools requires adequate teacher training since the lack of specific knowledge and technical skills can compromise the effectiveness of this curricular integration. In this context, it is necessary to observe the relevance of training educators so that they can explore the full potential of robotics in the development of skills such as computational thinking. The lack of specific training limits the ability of teachers to face the challenges that arise when trying to apply pedagogical practices involving emerging technologies. According to Passos et al. (2024), "the integration of robotics in the teaching of basic mathematics requires significant formative support for educators".

In addition, the choice of continuing education strategies has a direct impact on the quality of education offered. The adoption of specialized courses, workshops, and thematic seminars can provide teachers with practical experiences and theoretical deepening that facilitates the transition from theory to practice. These initiatives not only broaden educators' pedagogical vision but also strengthen their ability to create more interactive and engaging learning environments. In line with the current educational reality, Queiroz, Sampaio, and Santos (2021) state that "teacher involvement in continuing education is fundamental for the effective incorporation of computational thinking into classes."

Continuous training for teachers of educational robotics promotes constant adaptation to new technological demands. In this sense, it is important to highlight the need for educational institutions to develop policies that encourage this training, providing educators with a space for the exchange of experiences and collaborative learning. The report of experiences such as the one presented by Rossi and Aragón (2022) shows that well-founded practices can result in significant improvements in student engagement and teaching effectiveness.

Implications of inadequate teacher training in the use of educational robotics go beyond the individual, affecting the entire school dynamics. The lack of a solid foundation makes it difficult to implement interdisciplinary projects that could leverage student learning, reducing the understanding of the potential of robotics in the various areas of knowledge. This limitation in understanding can lead to resistance on the part of educators to integrate technologies into their practices.

In addition, the debates around teacher training reveal a pressing need to rethink the methodologies applied in pedagogy courses and educational technology specializations. Encouraging innovative approaches, such as project-based learning, can be a viable way to better prepare teachers. This type of approach allows educators to experience, in practice, how robotics can be integrated into the curriculum, contributing to demystifying technology as a barrier.

Acting on teacher training in robotics not only transforms educational practice, but also plays a fundamental role in preparing students for future challenges. A well-prepared student has critical and logical skills, factors that are developed through meaningful interactions with robotics. This preparation will strengthen the formation of citizens with the capacity to innovate and solve complex problems.

Finally, adequate teacher training in educational robotics is an essential pillar for the evolution of contemporary education. By fostering a learning environment in which technology is used critically and reflectively, educators will be contributing to the formation of a generation capable of adapting and thriving in a world of constant transformation. For this reality to materialize, effective actions must be taken towards valuing continuing education and aligning teaching practices with the requirements of the current scenario. It is time to redouble efforts to integrate educational robotics into everyday school life in an effective and meaningful way.

ACCESS TO ADEQUATE RESOURCES AND INFRASTRUCTURE

Educational robotics has been gaining prominence in contemporary pedagogical approaches, especially regarding the inclusion of autistic children. The implementation of this feature involves a series of challenges that transcend simple access to technology. It is essential to consider several factors, such as teacher training, the economic viability of schools, and the adequacy of physical space. The importance of preparing environments conducive to learning should be highlighted, as "adequate infrastructure is essential for the effective development of students' skills" (SILVA et al., 2024).

In the current educational landscape, many institutions face significant financial barriers, which limit the acquisition of robotics kits and necessary software. This reality compromises the diversity of methodologies that could be applied and, consequently, the richness of learning experiences. The current economic context requires that alternatives be sought, such as partnerships with companies in the technology sector. These collaborations can offer not only resources but also knowledge and technical support, fostering a more dynamic and interactive environment.

The concepts of educational robotics and digital citizenship are intertwined, proposing not only access to technology but also the formation of skills that are fundamental in the contemporary world. Santos and Luz (2023) state that "the usability of robotics in educational interventions is an important instrument to promote digital citizenship". This perspective highlights that robotics goes beyond being a mere teaching resource: it is a means to develop skills that guarantee the autonomy and inclusion of students.

The implications of this approach are wide-ranging. Firstly, by promoting inclusive and accessible education, educational robotics can enhance the learning of children with autism, offering them new forms of expression and socialization. In addition, by incorporating technology into classrooms, schools can stimulate critical reflection on the use of this tool, forming citizens who are more aware and prepared for the challenges of the digital age.

The debate around educational robotics also encompasses the resistance that many educators face in the face of technological innovations. Many education professionals are skeptical about the effectiveness of new methodologies. The continuing education of teachers becomes, therefore, a primordial aspect. Investing in teacher training helps them to adapt and integrate these technologies into their daily lives, favoring the learning and integral development of students.

Resistance to innovation, in addition to being a subjective issue, can be addressed through strategies that promote awareness and practical training. Holding workshops, for example, can allow teachers to become familiar with robotics and recognize its benefits. Thus, the faculty becomes an active agent in the transformation of education, creating a stimulating and inclusive learning environment.

In conclusion, the integration of educational robotics into everyday school life represents a unique opportunity for pedagogical innovation, but it requires coordinated actions and a favorable educational environment. Overcoming financial challenges and preparing the physical space are essential steps to ensure that this technology reaches all children, regardless of their particularities. By promoting inclusive education, education can fulfill its formative role, contributing to the construction of more capable and prepared citizens for the digital society that surrounds us.

FINAL CONSIDERATIONS

Educational robotics stands out as a powerful tool for the development of computational thinking among children, enabling them to experiment with concepts of logic, algorithms, and problem-solving in a practical and engaging way. Through interaction with robotics projects, students not only acquire technical skills but also develop essential competencies such as creativity, collaboration, and critical thinking. These elements are key to forming individuals capable of navigating effectively in an increasingly complex and technological world.

However, the implementation of robotics in education faces significant challenges that need to be overcome. Inadequate teacher training, coupled with the lack of adequate infrastructure in schools, limits the dissemination and effectiveness of these educational practices. For robotics to be a reality in all educational institutions, it is imperative to invest in continuous training programs for educators, which prepare them to integrate these technologies efficiently into their classes.

The promotion of public policies that ensure equitable access to educational robotics resources is also paramount. Many schools face financial difficulties in acquiring necessary equipment and materials, which creates an inequality in access to these learning opportunities. Therefore, there is an urgent need for actions that ensure that all students, regardless of their location or socioeconomic condition, can experience learning through robotics.

In the future, educational robotics is expected to evolve and become even more integrated into the school curriculum, adapting to the needs and interests of students. New

teaching approaches and methodologies can be developed, fostering a more dynamic and engaging learning environment. As technology advances, it will be critical for educators to stay up-to-date and empowered to take advantage of these innovations in their practices.

With the expansion of the use of robotics in education, new opportunities for future research arise. Investigating how different teaching approaches can impact student learning, or how robotics can be used to promote problem-solving skills in various disciplines, are promising areas to explore. In addition, the study of the impact of robotics on student motivation and engagement can contribute to more effective educational practices.

Finally, the educational community must continue to reflect on the future of robotics in education. With the potential to transform teaching and learning, robotics should not be seen only as a tool, but as a vital link in preparing students for the challenges of the twenty-first century. Thus, by strengthening teacher training, ensuring adequate infrastructure and fostering research, robotics will be able to fulfill its role in a full way, contributing to the formation of a more prepared and technological society.

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