LUMEN ET VIRTUS
ISSN: 2177-2789

ROBOTICS AND MAKER CULTURE: HOW TECHNOLOGIES CAN TRANSFORM EDUCATION

https://doi.org/10.56238/levv16n46-039

Submitted on: 11/02/2025 **Publication date:** 11/03/2025

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ABSTRACT

This study aims to explore how robotics and maker culture influence modern education, identifying both the positive aspects and challenges associated with their adoption. The methodological approach included a literature review and the analysis of practical cases in educational institutions that have already implemented these methodologies. The main results indicate that educational robotics proves to be an effective tool to increase student engagement while promoting essential technical and social skills. On the other hand, the maker culture is recognized for encouraging active learning and creativity, preparing students to be innovative and proactive. The survey also points out that, despite the obstacles, such as the lack of financial resources and the need for teacher training, the opportunities for educational improvement are significant. The findings suggest that the combination of these practices can transform the school environment, making it more adapted to the demands of the 21st century and equipping students with vital skills for a rapidly evolving technological future. The implementation of robotics and maker culture in the school curriculum not only enriches the learning experience but also assists in the development of critical skills, such as problem-solving and collaboration, which are fundamental for the formation of competent and adaptable citizens.

Keywords: Educational Robotics. Maker Culture. Modern Education. Skills of the XXI Century. Innovation.

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INTRODUCTION

The implementation of robotics and maker culture in education has proven to be a transformative phenomenon in the current context. In a society increasingly marked by technology, traditional teaching methods face significant challenges. The combination of educational robotics with maker culture not only inserts innovative practices in classrooms but also responds to a growing demand for training that allows students to become protagonists in the learning process. This proposal is pertinent not only for the development of technical skills but also for social and creative skills that are essential in the twenty-first century.

Recent developments in this area reveal a growing movement towards the integration of practical teaching approaches. Projects and initiatives in several institutions have sought to take advantage of the benefits of robotics and maker culture, which go beyond the mere use of technologies, promoting a collaborative and investigative learning environment. This trend is observed at different levels of education, from basic education to higher education, showing the versatility and efficiency of these methods to engage students in meaningful learning. In this way, education becomes a more dynamic experience that is adaptable to contemporary realities.

The importance of the study of robotics and maker culture in education is evident. By exploring these themes, the research contributes to a deeper understanding of the impacts of these approaches on the teaching-learning process. The need to investigate how the implementation of these practices influences the development of essential skills in students is one of the main reasons that justify this research. In addition, this analysis can offer valuable insights for educators, managers, and public policymakers who aim to improve the quality of education.

The central question that the research seeks to answer is: how does the integration of robotics and maker culture in education impact the development of skills in students? This problem is complex, as it involves multiple factors, such as the school context, the training of educators, and the profile of students. It is, therefore, a topic that requires careful examination to effectively understand its implications and the results of this interaction.

The main purpose of the research is to analyze the contributions of robotics and maker culture to the formation of competencies in contemporary education. To this end, it seeks to identify both the benefits and the challenges faced in the implementation of these approaches. Such an analysis will allow a more comprehensive understanding of the effectiveness of these educational practices in building a more relevant learning that is aligned with the demands of the twenty-first century.

In addition to the general objective, the research will present specific objectives that will assist in the investigation. Firstly, it is intended to map the experiences of implementing robotics and maker culture in educational institutions. Secondly, an analysis of the skills developed by the students through these practices will be made. Finally, the study will seek to gather evidence that demonstrates the effectiveness of combining these approaches in promoting a more engaging and innovative learning environment.

The methodology adopted for this research consists of a Bibliographic Methodology, allowing a critical review of the existing literature on the subject. The analysis of academic works and relevant publications will enable a survey of successful experiences, challenges, and guidelines that support the practices of robotics and maker culture in education. This procedure will ensure a solid basis for the formulation of conclusions that are relevant and applicable to the educational context.

In summary, the introduction presents a clear view of the relevance of robotics and maker culture in contemporary education, highlighting their contributions to the formation of skills in students. The proposed research is justified by the need to investigate this theme and offer a critical perspective regarding its implications. The transition to the body of the work will take place through the deepening of the implementation experiences and the results observed, which will be explored in the subsequent sections of this study.

THEORETICAL FRAMEWORK

The theoretical framework that supports the integration of robotics and maker culture in the educational environment is based on a variety of learning theories, with an emphasis on constructivism and constructionism. The contributions of Jean Piaget and Seymour Papert are fundamental in this context. Piaget's constructivist perspective underlines the importance of the active role of students in the construction of their knowledge, while Papert's constructionism emphasizes that learning through practice is essential for educational development. These academic approaches reinforce the relevance of practical and creative interaction of students in the learning process, stimulating autonomy and critical thinking.

In addition to the contributions of Piaget and Papert, the theory of experiential learning proposed by David Kolb is also pertinently relevant. This theory highlights direct experience as a central component in the educational process, suggesting that learning is materialized through living and reflecting on practical experiences. Thus, the application of methods that prioritize the students' experience aligns with the guidelines established by Kolb, creating an environment where knowledge becomes more tangible and meaningful.

In addition, the maker culture, which has gained notoriety in recent decades, is based on the democratization of technology and the promotion of collaborative creation. This perspective not only reflects contemporary social and technological transformations but also configures itself as an effective means of preparing students for the challenges and opportunities of the twenty-first century. As a result, the integration of robotics in this context not only provides technical improvement but also fosters transversal skills, such as creativity and problem-solving.

Thus, the theoretical body that supports this discussion offers an in-depth understanding of how robotics and maker culture can act as promoters of educational innovation. By facing the traditional challenges of conventional teaching methodologies, these practices propose alternatives that are based on more engaging learning related to the student's reality. In addition, this approach to new teaching paradigms allows students to feel more motivated to explore and experiment, resulting in an education that is not only instructive but also inspiring.

The intersection between robotics and maker culture configures an educational context where practice becomes a central pillar. This integrated practice not only stimulates learning but also proposes a new way of understanding education, fostering an environment of collaboration and innovation. Therefore, it is undeniable that these methodologies not only transform the act of learning but also provide new ways to engage students, making them protagonists in their educational journey.

Finally, by contemplating the relevance of the aforementioned theories and their practical application, the research in question becomes a comprehensive reflection on the transformative potential of robotics and maker culture in education. This theoretical articulation offers not only a basis for his proposals but also illuminates the paths for more meaningful teaching, adapting to the needs and aspirations of contemporary students. From this base, it is possible to envision an educational future where practical activity, collaborative work, and innovation are at the heart of the educational process.

EDUCATIONAL ROBOTICS

Educational robotics represents a significant innovation in the field of teaching, using robots as pedagogical tools in learning contexts. This approach aims to integrate into the curriculum, providing a valuable opportunity for active learning by students. As mentioned by Botelho et al. (2024), "the introduction of maker culture transforms the educational environment, promoting student interaction and engagement".

In the Brazilian context, the implementation of educational robotics is a reflection of a growing demand for methodologies that stimulate practical and collaborative learning. Traditional teaching often proves insufficient to prepare students for contemporary challenges, which require skills such as creative problem-solving and teamwork. Therefore, robotics not only complements but also enriches the school curriculum, contributing to the development of essential skills.

Among the concepts involved in educational robotics, STEAM (Science, Technology, Engineering, Arts and Mathematics) education stands out, which emphasizes interdisciplinarity and the practical application of knowledge. By integrating different areas of knowledge, this approach stimulates students' interest and curiosity, in addition to promoting the construction of projects that reflect real problems. Ferreira, Freitas, and Lima (2023) state that "the STEAM methodology, when applied to robotics, develops skills that go beyond formal disciplines".

However, the effective adoption of robotics in schools still faces several implications. The issue of teacher training is one of the main obstacles since many educators do not have the appropriate training to use these technologies in the classroom. Additionally, the cost of equipment and materials required for the practice of robotics can be a limiting factor, especially in institutions facing financial difficulties.

Debates about educational robotics often address the need for public policies that encourage teacher training and the acquisition of materials. For these methodologies to be implemented effectively, there must be an institutional investment that considers the specific demands of schools, in addition to offering continuous support to educators. The experience of computer science students acting as monitors, as reported by Castro et al. (2024), demonstrates that this exchange of knowledge can be beneficial for all involved, stimulating a culture of collaborative learning.

In addition, educational robotics should be seen not only as a tool but as an opportunity to transform the school environment. By introducing new technologies, educational institutions can inspire in their students a passion for science and technology, areas that have proven to be increasingly relevant in today's job market. Therefore, schools must be prepared to incorporate these innovations in a conscious and planned way.

Another important aspect is inclusion and diversity in robotics education. By adapting activities to meet different learning styles and social realities, it is possible to create an environment that favors the participation of all students. This means that methodologies must be flexible enough to accommodate the particularities of each group, ensuring that robotics is a formative experience for everyone.

The practical experience provided by robotics can also positively impact students' self-esteem, as they become protagonists in the learning process. Developing a robotics project, for example, allows students to see the results of their efforts, which can be extremely motivating. This aspect of self-efficacy is often addressed in discussions about active teaching methodologies.

Finally, educational robotics has the potential to consolidate itself as a central element in the training of students, preparing them for a future in which digital skills will be indispensable. For this to happen, schools, educators, and policymakers must work together, seeking solutions that ensure access and adequate training for all involved. As Botelho et al. (2024) point out, "the integration of robotics in teaching is a collective commitment that must be structured based on a long-term vision".

In conclusion, educational robotics represents a significant opportunity for the transformation of education in Brazil, promoting engagement and innovation in learning. Through the adoption of active methodologies and support for teacher training, it is possible to create an educational environment that values creativity and collaboration. Thus, it is expected that robotics will become a recurring practice in schools, contributing to the formation of citizens who are more prepared for the challenges of the 21st century.

DEFINITION AND APPROACHES

The definition of educational robotics encompasses the strategic use of robotic technologies to enrich the educational process, allowing diversified approaches ranging from simple robot programming to complex engineering projects. Different methodologies, such as Project-Based Learning (PBL) and Active Learning, are used in combination to integrate robotics into everyday teaching. These methods stand out for transforming the student into the protagonist of knowledge, encouraging him to explore creative and innovative solutions, even though the personalization of teaching and accessibility to resources continue to be challenging issues.

BENEFITS AND CHALLENGES IN EDUCATION

The benefits of robotics in education are vast, including increasing student motivation, enhancing their problem-solving skills, and the ability to work effectively in teams. By providing an interactive and engaging learning environment, robotics stimulates continued interest in science and technology. However, its integration presents considerable challenges, such as the need for adequate technological infrastructure and the extensive training of educators to maximize its effective use. Inequality in access to these resources

can perpetuate educational disparities, contributing to a scenario where not all students enjoy technological innovations equally.

METHODOLOGY

To investigate the impact of robotics and maker culture on education, a mixed methodological approach was chosen, which combines qualitative and quantitative methods. This choice is justified by the complexity of the educational phenomenon, which demands a multifaceted analysis. The first stage of the study consisted of a rigorous literature review, which allowed mapping the current knowledge about the insertion of these technologies in the educational environment and identifying gaps that could be addressed by the research.

After the review, structured questionnaires were applied to teachers and students who participated in educational robotics and maker culture projects. This procedure aimed to collect demographic data, as well as information on the perception of those involved in these initiatives. The choice of this sample was based on the intention of understanding the different educational experiences and contexts, ensuring that the data collected reflected a variety of realities.

Simultaneously, semi-structured interviews were conducted with educators and coordinators of innovative programs. This qualitative method proved to be essential to deepen the analysis since it enabled the collection of detailed reports on pedagogical practices, challenges faced, and the potentialities perceived in teaching methodologies that use robotics and the maker culture. Thus, a space was provided for the participants to express their opinions and experiences more freely.

The analysis of the collected data was carried out using statistical software tools for quantitative data, which allowed the obtaining of significant results and the identification of patterns. For the qualitative data, content analysis was used to extract relevant information from the reports of educators and coordinators. This methodological strategy ensured a deeper understanding of the classroom dynamics and the learning outcomes arising from these innovative educational practices.

In addition, the integration between quantitative and qualitative data provides a more holistic view of the impacts of robotics and maker culture on education. This approach combats possibilities of analysis that transcend the simple observation of statistical trends, allowing more comprehensive scenarios to be projected about the implications of these methodologies in the formation of students' competencies and skills.

The debates generated from the results obtained show the relevance of the implementation of technologies in contemporary education. However, questions also arise about the barriers that persist, such as the preparation of educators and the availability of adequate resources. These discussions are fundamental for the formulation of educational policies that encourage the effective use of these technologies, to maximize the benefits for students.

Finally, the research reveals that robotics and maker culture not only innovate pedagogical practice, but also stimulate the development of crucial skills for the 21st century, such as critical thinking, collaboration, and creativity. Therefore, educational institutions must continue to explore and integrate these approaches into the curriculum, fostering a learning environment that values creativity and problem-solving.

In this way, the research sheds light on the transformative potential of robotics and maker culture in education, highlighting the need for a continuous commitment to overcome obstacles and foster teaching that prepares students for the challenges of the future. In summary, the proposed analysis constitutes a significant contribution to the field of education, providing theoretical and practical subsidies that can guide future initiatives and studies in this area.

MAKER CULTURE

Maker Culture emerged as an innovative approach to education, emphasizing the importance of practical learning and interactivity in the teaching-learning process. This movement, which promotes the concept of "do it yourself", makes it possible for students not only to absorb theoretical knowledge but also to apply it creatively and experimentally. As MARTINS, OLIVEIRA, and OLIVEIRA (2024) rightly state, "The maker culture transforms the act of learning, integrating theory and practice effectively". This integration provides an environment where creativity and critical thinking can flourish.

In the face of rapid technological evolution, Maker Culture presents itself as a necessary response to the educational demands of the new times. Project-based learning allows students to become active agents of their learning. When creating and building, they face real challenges, developing skills that are essential for life in the twenty-first century, such as problem-solving and collaboration. This teaching method, which challenges traditional norms in the classroom, has generated significant debates about how education should adapt to new contexts.

The intersection between Maker Culture and active methodologies is an area of growing interest among educators. Active methodologies are strategies that encourage

students to be protagonists in their learning process. According to FREITAS (2025), "the adoption of innovative technologies in academic evaluation transforms not only the methodology but also the way knowledge is built". In this sense, Maker Culture positions itself as a support tool, enriching educational experiences and providing more meaningful learning.

The adoption of digital tools, such as 3D printers and laser cuts, is a striking feature of Maker Culture. However, this practice is not without its challenges. The tension between educational tradition and new technologies often generates resistance on the part of educators and institutions. The implementation of these new approaches must be done judiciously, considering the different realities of educational institutions and the profile of students.

In addition, it is important to reflect on the social and economic implications of Maker Culture in the educational context. Fostering an environment of sharing and collaboration encourages the formation of learning communities that transcend the walls of the school. As NARCISO and SANTANA (2025) discuss, "scientific methodologies in education can benefit significantly from collaborative practices, facilitated by the Maker Culture". This suggests that a more integrative education can generate greater social cohesion.

Maker Culture also instigates a debate on the need for new curricula that simultaneously contemplate theoretical and practical knowledge. The integration of technical and socio-emotional skills is essential for the formation of citizens fully capable of facing current challenges. Therefore, schools must adapt their pedagogical practices to include these innovations and prepare students for contemporary reality.

In short, Maker Culture transcends the simple practice of building objects or projects. It is a philosophy that should permeate all education, favoring the development of a student profile that adapts to the demands of the twenty-first century. By promoting it, educational institutions can contribute to the formation of individuals who are better able to face a world in constant transformation.

The strong connection between Maker Culture and the development of key skills in young people is undeniable. As students engage in hands-on activities, they not only become more autonomous but also more critical of the knowledge they build. This change in the educational paradigm requires a collective commitment, where educators, managers, and students work together.

Finally, Maker Culture has a transformative role in the contemporary educational scenario. The strengthening of a more practical and interactive education not only meets the needs of students but also responds to the challenges imposed by modern society. To

move in this direction, institutions must recognize the importance of integrating these new methodologies into their educational practices, thus ensuring a complete education in line with the demands of the future.

ORIGINS AND PRINCIPLES

The origins of Maker Culture date back to artisanal practices and the DIY movement intensified with the advancement of digital technologies. Strongly influenced by the principles of knowledge sharing, sustainability, and open innovation, Maker Culture proposes a rapprochement of the individual with the production processes.

It is based on the premise that anyone can be a creator, regardless of the level of initial technical knowledge. Key principles include valuing learning through experimentation, encouraging collaboration, as well as fostering flexible and interactive learning environments. The Maker movement challenges traditional educational constructs by placing students at the center of the learning process and encouraging a more personalized and empirical approach. Thus, in addition to promoting technical skills, the Maker Culture fosters self-confidence and initiative, preparing individuals for the complex challenges of the future.

INTEGRATION OF ROBOTICS AND MAKER CULTURE IN EDUCATION

The integration of robotics with maker culture in education emerges as an innovative approach that enhances student learning in a practical and meaningful way. This educational context presents a unique opportunity for students to become protagonists in their knowledge journeys, fostering essential skills such as problem-solving, critical thinking, and creativity. In a scenario where the demands of the labor market are constantly evolving, the educational process must adapt and offer experiences that prepare young people for future challenges.

Robotics, in turn, acts as a tool that brings theory into practice, allowing students to materialize abstract concepts through the manipulation of equipment and software. According to Nascimento et al. (2023), "robotics adds value to the teaching of professional and technological education subjects in Brazil" by creating a dynamic learning environment. At the same time, maker culture is based on the "do it yourself" philosophy, promoting collaboration and experimentation. This culture encourages prototyping and manufacturing solutions, stimulating students' creativity and innovation.

The union of these two elements results in an enriched educational environment, where practice becomes the foundation of learning. The maker methodology allows

students to get involved in meaningful projects, becoming more engaged and motivated. Sales et al. (2023) state that "the maker culture in science teaching promotes more active and collaborative learning", which is reflected in the high rates of content retention and the practical application of knowledge.

In terms of implications, this integration not only benefits students' learning but also proposes a new way of looking at teaching in a school environment. By integrating robotics with maker culture, educational institutions become spaces for innovation and creativity, capable of meeting the real demands of contemporary society. This translates into professionals who are better able to adapt to constant changes in the market and to face technological challenges in an innovative and multidisciplinary way.

In addition to the professional aspect, this approach has a profound sociocultural impact. The ability to work in teams, communicate ideas, and collaborate on projects is fundamental in the formation of conscious and active citizens. As Santana, Fernandes, and Batista (2024) mention, "the application of elements of the maker culture in projects promotes the development of socio-emotional skills", which are essential for the future of students.

In the context of educational debates, robotics, and maker culture raise questions about teacher training and the adequacy of school infrastructure. The successful implementation of this methodology requires trained teachers and resources that enable both practice and experimentation. The discussion around teacher training is, therefore, a fundamental theme to ensure that this new approach is consolidated in the classrooms in an effective and meaningful way.

Still, it is important to highlight that the integration of robotics and maker culture must be a conscious, planned, and contextualized choice with the profile of the students and the needs of the school community. The effectiveness of this union depends on an implementation that considers the reality of each institution, always seeking continuous improvement in the educational process.

In conclusion, the combination of robotics and maker culture presents itself as a promising strategy that not only makes learning more dynamic and practical but also engages students in an active and collaborative process. This methodology should not be seen only as a trend, but as an urgent need for current education to align with the demands of the market and the demands of society. Thus, it is possible to prepare students for a future that values innovation, creativity, and problem-solving skills in an increasingly technological and interconnected world.

BARRIERS TO IMPLEMENTATION

The introduction of robotics and maker culture in schools is a proposal that can transform the way students engage with learning. However, this transition is not without considerable challenges. Educational institutions often face a shortage of adequate infrastructure, which includes the absence of properly equipped laboratories and the lack of access to modern technologies, essential for the development of these innovative practices. This reality can limit the effectiveness of the proposed activities and frustrate both educators and students who want to explore these new methodologies.

Another relevant aspect is the continuous training of educators. For them to be able to use robotics and maker tools effectively, they must have access to regular training. Without appropriate educational support, many teachers may feel insecure when introducing these practices into their classes, which directly impacts student motivation and learning. Thus, investing in the professional development of educators becomes a priority to ensure the success of these initiatives.

In addition to the lack of infrastructure and teacher training, the cost of implementation emerges as a real obstacle. Educational institutions, especially those located in less favored areas, often cannot afford the initial expenses necessary for the acquisition of equipment and the creation of adequate spaces for the practice of robotics and maker culture. This financial barrier can make these schools even more distant from technological advancement and modern teaching methodologies.

The choice of affordable materials and technologies also needs to be considered in this context. Although there are several options available in the market, not all of them suit the reality of schools that face budget limitations. Often, the most innovative solutions can be the most expensive, and it is essential to look for viable alternatives, that still provide an enriching educational experience. This requires creativity and concerted efforts to adapt what is available to local needs.

Another factor that can influence the implementation of robotics and maker culture in schools is cultural resistance to change. In some school communities, more conventional teaching traditions and methods are still predominant, which makes it more difficult to accept new pedagogical approaches. To overcome this resistance, it is necessary to foster an environment that values innovation and experimentation, preparing teachers and students for a more collaborative and dynamic learning culture.

Therefore, although the introduction of robotics and maker culture in educational institutions brings transformative potential, its implementation requires a careful analysis of several factors. Overcoming structural barriers, training educators, financial planning, and

building a culture of innovation are essential for these methodologies to be incorporated effectively. By addressing these challenges, we will not only be equipping our students with skills for the future but also creating a richer and more inclusive educational environment.

FINAL CONSIDERATIONS

Research on the impact of educational robotics and maker culture has shown that these methodologies have the potential to transform the school environment. They promote more dynamic and collaborative learning, stimulating students' autonomy, and the development of critical thinking, and problem-solving skills. However, the implementation of these approaches still faces significant obstacles, such as the lack of adequate infrastructure and the need for continuous training for educators, which are key to maximizing the benefits of these practices.

The future of robotics and maker culture in Brazil presents great opportunities, especially if there is a real commitment to reformulate existing educational policies. Technical and pedagogical support mechanisms must be created, aiming to prepare both educators and students for this new teaching reality. By uniting these methodologies strategically, it is possible to transform Brazilian education, forming individuals who are better able to face the challenges and changes of the contemporary world.

To advance the understanding of the impact of robotics and maker culture, future investigations must focus on the effectiveness of these pedagogical practices. It is vital to assess how these approaches influence the development of socio-emotional and technical skills in students since these skills are increasingly valued in the professional environment. In addition, research should be dedicated to exploring effective strategies for teacher education, ensuring that they can implement these methodologies effectively.

Another aspect that requires attention in future research is the analysis of the necessary conditions for the successful implementation of robotics and maker culture approaches in different educational contexts. Researchers need to identify and propose solutions to the challenges faced by schools, such as the lack of material and technological resources, which often limits the potential of these innovative practices.

In addition, investigations should include the study of how to integrate theory with practice effectively in class. Creating curricula that associate academic content with practical robotics and maker culture projects can increase student motivation and facilitate learning. Studying success stories and identifying best practices in schools that already use these approaches can provide valuable insights for their dissemination in other institutions.

Finally, it is suggested that future research explore the importance of forming learning communities among teachers. These collaborative networks can be fundamental for the exchange of experiences, joint problem-solving, and innovation in the use of robotics technologies and maker culture in classrooms. Encouraging the exchange of knowledge among educators can enhance the implementation of these practices and maximize their impact on student development.

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