IOSR Journal of Humanities and Social Science (IOSR-JHSS)
Volume 30, Issue 7, Series 4 (July, 2025) 01-06
e-ISSN: 2279-0837, p-ISSN: 2279-0845.
www.iosrjournals.org

ECO TECH PROJECT: Robotics and Sustainable Technologies for Inclusive Environmental Education in the School Context

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Abstract:
Background: *In the face of contemporary environmental challenges and the growing need for sustainable educational practices, this study presents the Eco Tech Project as an innovative proposal that integrates educational robotics and sustainable technologies within an inclusive pedagogical framework. The project aligns with global agendas such as the Sustainable Development Goals and Brazil's commitment in hosting the COP30, highlighting the role of schools as key spaces for environmental awareness and social transformation.*
Materials and Methods: *The study employed a qualitative approach supported by a bibliographic review as the main research procedure, enabling a comprehensive analysis of the theoretical foundations related to educational robotics, environmental education, sustainability, and inclusion. In addition, a narrative account of the main actions developed through the Eco Tech Project was presented, aiming to bridge theoretical insights and practical applications.*
Results: *The general objective was to demonstrate how educational robotics can be used as an inclusive tool to promote environmental awareness, stimulate sustainable practices, and encourage the active participation of all students, regardless of their individual specificities, within the school environment. The theoretical framework was organized into three key sections: (1) Educational Robotics as a Strategy for Environmental Awareness, (2) Sustainable Technologies and Robotics Applied to Waste Management in Schools, and (3) The Eco Tech Project: Experience Report.*
Conclusion: *The study also made it possible to observe the influence of sustainable technologies in the school environment, especially when implemented through activities that promote experimentation, creativity, and the solution of real-world problems. The inclusion of recyclable materials in the development of robotic prototypes fostered a more reflective and innovative perspective in environmental education, integrating academic knowledge with societal needs.*

Keywords: *educational robotics, sustainability, environmental education, inclusion.*

Date of Submission: 02-07-2025 Date of Acceptance: 11-07-2025

I. Introduction

The growing concern regarding climate change, environmental degradation, and the urgent need to reassess consumption patterns and waste disposal practices has stimulated targeted actions in the field of environmental education within school settings. In this context, the **Eco Tech Project** emerges as an innovative initiative that integrates educational robotics and sustainable technologies, aiming to promote inclusion and the development of critical and environmentally conscious citizens. The project aligns with the principles advocated in international conferences, such as COP30, which will be held in Brazil, reinforcing a commitment to the construction of a socially just and environmentally responsible society.

The project's proposal is directly connected to the Sustainable Development Goals (SDGs), particularly those related to quality education, the reduction of inequalities, and the promotion of actions to combat global climate change. By fostering educational approaches that interconnect technology, sustainability, and inclusion, the **Eco Tech Project** seeks to contribute to the cultivation of an environmental culture in schools, encouraging student protagonism and equitable access to knowledge. Through robotics, students engage in learning that is

practical, creative, and collaborative, thereby fostering the development of both technical and socio-emotional skills aligned with the challenges of the 21st century.

The project also acknowledges the school's transformative potential as a space for experimentation and innovation, especially when it acts in alignment with global issues discussed in forums such as COP30, which emphasize the importance of local solutions for planetary-scale challenges. The methodological approach adopted for the execution of this study was based on a qualitative perspective, due to its capacity to deepen the understanding of phenomena and to value the contexts in which they occur. A bibliographic review was chosen as the primary research method, with the aim of identifying relevant scientific works on educational robotics, sustainability, and inclusion. Additionally, an experience report was included to illustrate the main actions carried out within the context of the **Eco Tech Project**, allowing for the analysis of its practical implementation and its effects in everyday school life.

The general objective of this study was to demonstrate how educational robotics can serve as an inclusive tool to foster environmental awareness, promote sustainable practices, and support the participation of all students, regardless of their individual characteristics, in the school environment. Specifically, the study aimed to: (1) develop inclusive educational activities that integrate robotics as a means to promote environmental awareness among students, considering diverse learning profiles and focusing on the proper disposal of batteries and electronic waste; (2) implement sustainable technologies associated with robotics in pedagogical activities that promote the collection, reuse, and reconfiguration of electronic waste, ensuring accessibility, engagement, and active participation of all students, while fostering ecological practices in the school context; and (3) document the experience carried out through the **Eco Tech Project**.

To ensure clarity in the structure of this study, the article is organized into four main sections: the **Introduction**, which presents the context and objectives of the research; the **Materials and Methods** section, which details the methodological approach adopted; the **Theoretical Framework**, composed of three subsections analyzing the project's central themes; and finally, the **Final Considerations**, which summarize the main results and propose directions for future research.

II. Material And Methods

The present research adopted a qualitative approach, given its suitability for the detailed analysis of complex educational phenomena, particularly concerning the integration of robotics and sustainable technologies into inclusive pedagogical practices. The qualitative analysis enables a more sensitive and interpretative understanding of meanings, experiences, and contexts, proving especially valuable when the objective is to construct meaning from specific educational situations. According to Gerhardt and Silveira (2009), this approach seeks to interpret reality through the subjective analysis of phenomena, prioritizing the understanding of underlying processes rather than the quantification of data. As a methodological procedure, a bibliographic review was selected, with the aim of gathering, analyzing, and synthesizing previously published scientific research related to educational robotics, environmental education, school inclusion, and sustainability.

The choice of this procedure aligns with the principles of exploratory research from a qualitative perspective, as discussed by Lösch, Rambo, and Ferreira (2023), who emphasize that literature reviews provide a robust theoretical foundation for preliminary investigations and the development of innovative proposals. This review enabled the identification of experiences, methodologies, and theoretical frameworks that underpin the Eco Tech Project, thus facilitating a critical analysis of the contributions and limitations of current practices. In addition to the theoretical analysis, the methodology also involved the preparation and development of an experience report on the activities of the Eco Tech Project, which integrates robotics and sustainability within the school context with a focus on inclusion.

The construction of this report was essential to demonstrate the feasibility of the proposal in concrete teaching situations, highlighting the planning, implementation, and observed impacts on pedagogical interactions. This methodological approach adds value to the research by integrating theory and practice, supporting the organization of innovative experiences that may be replicated or adapted in other educational institutions, thereby expanding the social and scientific impact of the investigation.

III. Theoretical Framework

The theoretical framework of this study was developed around three central topics, organized in a manner that ensures a logical progression between the concepts discussed and the objectives established. Section 3.1, entitled **Educational Robotics as a Strategy for Environmental Awareness**, examines the potential of robotics as an innovative pedagogical tool in the promotion of inclusive environmental education. Section 3.2, titled **Sustainable Technologies and Robotics Applied to Waste Management in Educational Institutions**, explores in depth the connection between sustainable practices, the reuse of electronic materials, and their integration with robotics within the school environment. Finally, Section 3.3, entitled **Eco Tech Project: Experience Report**, provides a structured description of the activities carried out within the context of the project, enabling a practical

analysis of the concepts addressed in the previous sections and highlighting their effective and inclusive pedagogical application.

3.1 Educational Robotics as a Strategy for Environmental Awareness

Educational robotics has increasingly established itself as an effective pedagogical tool for promoting environmental awareness in educational institutions, particularly when incorporated into inclusive initiatives tailored to specific contexts. By enabling the development of projects focused on the responsible disposal of toxic waste—such as batteries, electronic components, and related materials—robotics enhances learning opportunities and reinforces the connection between scientific knowledge and socio-environmental responsibility. Eiras, Rangel, and Cordeiro (2023) emphasize that the use of robotics in environmental education fosters the assimilation of sustainable values, as students begin to actively engage with real-world challenges, proposing both technical and creative solutions.

In this context, the integration of educational robotics with the STEAM approach has been highlighted as an effective strategy to foster meaningful learning and incorporate socio-environmental themes into the school curriculum. Fernandes and Zanon (2022) argue that when students design robotic prototypes focused on sustainability and social responsibility, they are encouraged to critically reflect on the role of technology in shaping a more equitable and harmonious future. Moreover, the use of repurposed materials—such as cardboard, Amazonian seeds, and other organic waste—in the construction of robotic structures strengthens interdisciplinarity and promotes ecological practices through a formative and inclusive lens. In such initiatives, meaningful learning is not limited to conceptual acquisition; it is realized through experimentation and the resolution of concrete problems. As Guilhen (2023) asserts, the intentional application of robotics in the school environment allows students to cultivate autonomy, critical thinking, and a sense of belonging, especially when diverse learning styles and paces are acknowledged and valued. Thus, educational initiatives that incorporate robotics as an accessible and collaborative language foster equity and encourage the participation of all individuals involved in the teaching-learning process.

Complementing this perspective, Motta, Gurczakoski, and Teófilo (2024) conducted a systematic mapping study that highlights the potential of robotics as a central element in interdisciplinary practices at the primary education level, especially when integrated into projects focused on environmental issues. The analysis revealed that successful experiences across various Brazilian educational institutions engaged students from diverse social and cognitive backgrounds, underscoring the importance of pedagogical approaches that coherently and transformatively integrate technology, inclusion, and sustainability. Finally, Soares and Vasconcelos (2018) argue that the inclusion of robotics in environmental education initiatives fosters a shift from passivity to action—transforming students into active agents of change. The development of robots for waste collection, sensors for sorting materials, or environmental monitoring systems exemplifies how technology can facilitate educational experiences that are sensitive, accessible, and aligned with the Sustainable Development Goals (SDGs). When designed with inclusive pedagogical intent, educational robotics contributes meaningfully to the formation of critical, responsible, and environmentally engaged individuals.

3.2 Sustainable Technologies and Robotics Applied to Waste Management in Schools

The advancement of digital technologies has fostered innovative educational practices that play a significant role in promoting sustainability within the school environment. When educational robotics is integrated with the application of sustainable technologies, it emerges as an effective solution for addressing waste management in an active and meaningful manner. Nunes (2024) emphasizes that the didactic use of technology, combined with critical environmental education approaches, contributes to the development of a stronger ecological culture among students, encouraging responsible and conscious behavior from the early years of schooling.

A key aspect of this process involves the automation of selective waste collection procedures and the reuse of electronic components considered obsolete or discarded. The experience described by Pereira and Bastos (2019), which employed Arduino boards and Scratch programming as the foundation for educational robotics initiatives, illustrates how the combination of basic programming principles with recyclable materials can generate innovative solutions to concrete environmental problems. These initiatives, in addition to fostering technical learning, raise students' awareness of the life cycle of electronic products and the need for proper disposal.

Santos Neto (2024), in presenting the **Botsu** project, highlights that the use of recyclable waste in the construction of robotic prototypes contributes not only to environmental sustainability but also to equity in access to educational technologies. This perspective enables students from diverse social backgrounds to actively engage in educational processes aimed at solving environmental issues, promoting collaboration, creativity, and computational thinking. In this context, robotics serves as a catalyst for educational inclusion and collaborative engagement in the pursuit of shared goals. A critical understanding of the environmental impacts of electronic waste must also be intentionally incorporated into pedagogical practices. Fraguas, Gonzalez, and Martins (2019) discuss the importance of teacher training programs aimed at equipping educators to implement contextualized

and sustainable educational activities. Their analysis of secondary school teachers reveals that, although the topic is widely recognized as relevant, there is often a lack of methodological resources to effectively address it in school settings. It is therefore essential that continuing education initiatives include the use of robotics as a pedagogical tool to investigate waste management and promote the conscious use of technology.

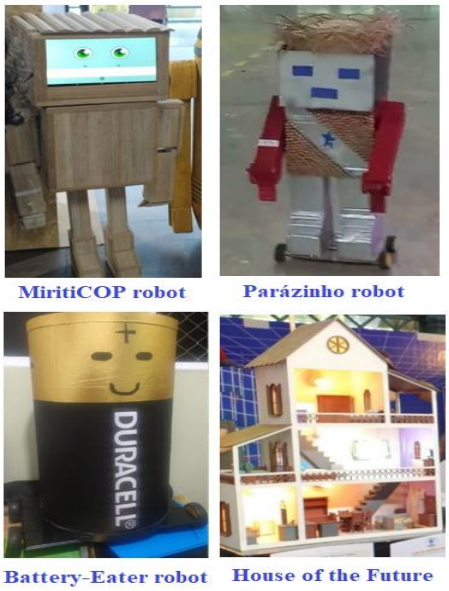
Additionally, Germano et al. (2022) and Alencar (2020) demonstrate that the adoption of practices involving the reuse of electronic and/or organic waste in public educational institutions has the potential to reframe traditional knowledge and transform pedagogical routines. The implementation of active learning strategies—focused on experimentation and project-based learning—fosters student protagonism and contributes to the development of individuals who are more aware of their socio-environmental responsibilities. By promoting robotics as an accessible, collaborative, and environmentally responsible resource, the school becomes a space for innovation and commitment in addressing the contemporary challenges of sustainability.

3.3 Eco Tech Project: Experience Report

The Eco Tech Project, implemented at *Colégio Estadual Paes de Carvalho (CEPC)*, located in Belém do Pará, illustrates how educational robotics can foster sustainable and inclusive pedagogical practices by integrating technological innovation, environmental awareness, and youth protagonism. Aligned with Alencar's (2020) proposal advocating the use of active methodologies in environmental education, the project involved students from the Robotics Club in the development of practical solutions using recyclable materials such as cardboard, açaí seeds, PET bottles, discarded electronic components, and Arduino boards. The accessibility and reuse of these materials reinforce a commitment to sustainability and the democratization of technological knowledge, while also highlighting the cultural and ecological specificities of the Amazon region.

Among the prototypes developed by students, four main creations stand out: the MiritiCOP robot, the Parázinho robot, the Battery-Eater robot (Papa Pilhas), and the House of the Future (Figure 1). The *MiritiCOP*, made from *miriti* fiber (*Mauritia flexuosa*), functions as a bilingual translator and has become a symbol of sustainable innovation in the Amazon during COP30. *Parázinho*, constructed from açaí seeds and cardboard, operates as a conversational robot designed to raise environmental awareness and stimulate dialogue about the Amazon. Both projects incorporate inclusive and accessible practices, with *Parázinho* advancing toward the implementation of a version capable of translating into Brazilian Sign Language (LIBRAS), as suggested by Eiras et al. (2023), who emphasize the transformative potential of educational robotics when rooted in local contexts and socio-environmental themes.

Figure 1 – Prototypes from the ECO TECH Project



Complementing these initiatives, the Battery-Eater robot (Papa Pilhas) was designed as an educational tool for collecting electronic waste in schools. Operated via a mobile application, it offers an interactive experience in appropriate waste disposal. This initiative aligns directly with Germano et al. (2022), who highlight the potential of robotics to promote electronic waste reuse and contribute to the formation of environmentally conscious and engaged students. The House of the Future is a prototype for sustainable home automation, managed through Arduino and remotely controlled via an app, showcasing—within the school environment—the connection between energy efficiency and environmental citizenship.

The trajectory of the Eco Tech Project has been consolidated through participation in scientific events and technology competitions, notably achieving first place at the *Hackathon Startup Pará* with the Energy Save Project, and receiving awards in the 2023 and 2024 editions of *TechCamp Pará*. The exhibition of prototypes at events such as the *Annual Meeting of the Brazilian Society for the Advancement of Science (SBPC)*, the *Book Fair*, and the *Science and Technology Caravan* has strengthened public recognition of the initiative. These experiences demonstrate how the interaction between science, technology, and local culture can stimulate environments of youth protagonism and appreciation for school-based knowledge. Such actions reflect the emphasis placed by Nunes (2024) on the urgent need to promote educational practices that are environmentally responsible, supported by digital technologies.

The integration of robotics into the school curriculum through initiatives such as Eco Tech underscores the transformative role of technological education when aligned with the students' social and environmental realities. As argued by Pereira and Bastos (2019), the use of Arduino and programming platforms like Scratch fosters not only technical knowledge acquisition but also the development of computational thinking, creativity, and critical consciousness. By engaging public school students in collective construction activities, the project advances digital skills while also promoting active citizenship and socio-environmental involvement, establishing the school as a space for innovation, inclusion, and sustainability.

Ultimately, the Eco Tech Project represents a meaningful experience demonstrating how educational robotics can serve formative, inclusive, and environmentally committed objectives. It offers a platform that enables students to participate in global discussions—such as those promoted by COP30. The valorization of local knowledge, reuse of regional materials, and commitment to accessible innovation illustrate the viability of reimagining the educational process through a critical and transformative lens. Such initiatives embody what Alencar (2020) defines as the restructuring of sustainable pedagogical knowledge, positioning the Amazon as a core site for the generation of knowledge and technology with significant social relevance.

IV. Conclusion

The research successfully achieved its established objectives by constructing the theoretical framework based on a qualitative approach and employing the bibliographic review as its methodological procedure. This analysis enabled a profound understanding of how educational robotics can function as an effective and inclusive tool to foster environmental awareness within the school context. The general objective, which aimed to demonstrate the potential of robotics as a tool to promote sustainable practices and inclusion of all students regardless of their particularities, was fully met, as were the specific objectives related to the implementation of educational actions and the use of sustainable technologies.

The study revealed that robotics, when integrated into pedagogical practices designed with inclusive intentionality, facilitates the creation of a more accessible, collaborative educational environment aligned with current socio-environmental challenges. The inclusion of diverse learning profiles in proposals addressing the proper disposal of hazardous waste and the reuse of electronic materials demonstrated not only the technical feasibility of the initiative but also its pedagogical and social significance. Educational robotics proved to be an efficient tool to engage students in ecological actions that extend beyond the school environment, fostering a strengthened sense of belonging and environmental responsibility.

The study also highlighted the influence of sustainable technologies within the school setting, especially when implemented through activities that promote experimentation, creativity, and problem-solving. The incorporation of recyclable materials in the construction of robotic prototypes fostered a more reflective and innovative perspective in environmental education, integrating academic knowledge with societal needs. The Eco Tech Project initiative demonstrated the feasibility of creating inclusive experiences that meaningfully and innovatively integrate technology, sustainability, and citizenship.

As a continuation of this investigation, empirical studies are proposed to analyze the practical effects of implementing the Eco Tech Project in public educational institutions, with emphasis on its impact on learning, student engagement, and changes in pedagogical practices. Comparative analyses of diverse educational contexts could also contribute to refining the proposal and expanding public policies aimed at inclusive environmental education mediated by technologies. By consolidating consistent concepts and methodologies, the present study offers significant contributions to researchers, educators, and administrators committed to fostering a more sustainable, inclusive, and innovative educational institution.

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