CINTED-UFRGS Revista Novas Tecnologias na Educação

Assessing the Impact of AI Education on Elementary School Students' Ethical and Sustainable Perceptions

Wellington Gomes Pereira, Universidade Federal Rural de Pernambuco, wellington.gpereira@ufrpe.br, https://orcid.org/0009-0005-0457-3628
Thomas Jefferson do Nascimento Ferreira, Universidade Federal Rural de Pernambuco,
thomas.jefferson@ufrpe.br, https://orcid.org/0009-0007-2311-5811
Celio Rocha, Universidade Federal Rural de Pernambuco,
celio.rocha@ufrpe.br, https://orcid.org/0009-0008-0049-1248
Ruallyson Felype Travassos de Moura, Universidade Federal Rural de Pernambuco,
ruallyson.felype@ufrpe.br, https://orcid.org/0009-0001-6347-3505
Wellington Luis da Cunha, Universidade Federal Rural de Pernambuco,
wellington.lcunha@ufrpe.br, https://orcid.org/0009-0006-7869-098X
Gabriel Candido da Silva, Universidade Federal Rural de Pernambuco, gabcandidods@gmail.com, https://orcid.org/0000-0002-7470-8613
Rodrigo Lins Rodrigues, Universidade Federal Rural de Pernambuco, rodrigomuribec@gmail.com, https://orcid.org/0000-0002-3598-5204

Abstract: Although Artificial Intelligence and robotics are essential in Basic Education, their teaching frequently focuses on technical aspects, neglecting ethical and environmental debates. In this regard, this article reports and evaluates a pedagogical experience developed with students aged 10 to 12 at UTEC Gregório Bezerra, in Recife, grounded in Project-Based Learning and utilizing Scratch and Lego Mindstorms EV3 to teach Machine Learning integrated with ethics and sustainability. The methodology articulated theoretical and practical classes, using Kahoot for engagement and Likert-scale pre- and post-tests for data collection. The results suggested an increase in the class's global perception average from 3.80 to 4.12, with the largest difference occurring in the understanding of human responsibility behind algorithms and in the recognition of sustainability as a technological requirement, with the reflective decline in the perception of AI neutrality suggests an emerging critical thinking. Therefore, it is concluded that the intervention showed promising potential in fostering the students' ethical awareness, who began to see technology as a tool for socio-environmental transformation.

Keywords: Artificial Intelligence in Education; Educational Robotics; Elementary Education

1. Introduction

The integration of Artificial Intelligence (AI) and educational robotics into elementary school learning environments represents a promising pedagogical strategy. However, the objective extends beyond technical instruction, it encompasses preparing children to comprehend and navigate the complex intersections of technology, ethics, and sustainability. As Dabbagh et al. (2025) emphasize, understanding AI and applying it responsibly is paramo unt for the future of younger generations, and this comprehension is inherently linked to sustainability since AI, as a powerful tool, possesses the dual potential to optimize resources or exacerbate environmental impacts. Consequently, AI education must combine technical skills with critical reflections on how algorithmic systems can foster a sustainable future.

In this context, demystifying the inner workings of these technologies is essential. Akgun and Greenhow (2022) argue that the ethical challenges of educational AI, including privacy issues, surveillance, bias, and discrimination, must be explicitly identified and presented to both educators and students, and to achieve this, introducing Machine Learning (ML) concepts is necessary, since by understanding how a system is "trained," children can recognize that AI is not an act of magic, but rather a direct reflection of the data it processes.

To translate these abstract concepts into tangible experiences for young learners, the use of robotics and programming is crucial, and pairing the Lego Mindstorms EV3 with Scratch, a block-based programming platform developed by the Lifelong Kindergarten group at the Massachusetts Institute of Technology (MIT), establishes the ideal hands-on environment. According to Wangenheim et al. (2014), Scratch enables children to design animations, interactive stories, and games, facilitating the seamless integration of graphics, images, photographs, music, and sound.

Instructional activities combining Scratch programming and Lego Mindstorms EV3 robotics have proven highly effective in developing students' cognitive skills and computational thinking competencies. This is supported by Korkmaz (2016), whose findings indicate that educational programs based on interactive games with Scratch positively enhance students' logical-mathematical thinking skills, while further noting that design activities using Lego Mindstorms EV3 yield significant cognitive gains compared to traditional teaching methods. Therefore, engaging in practical machine learning training allows children to experience these concepts firsthand, positioning them as young computer scientists.

Furthermore, AI education for elementary students must inherently address ethics and sustainability, given the transformative potential of these experiences in shaping conscious and responsible citizens. Akgun and Greenhow (2022) stress that cultivating a future generation where diverse, inclusive citizens can contribute to AI development requires providing elementary and high school students and teachers with opportunities to study AI through curricula centered on both technology and ethics.

In Brazil, however, the term "Artificial Intelligence" only explicitly appears within the High School guidelines of the National Common Curricular Base for Computing. Foundational AI skills, such as algorithms, are addressed earlier in elementary education, for instance, the Computational Thinking axis of the BNCC for grades 1 through 5 includes competency (EF15CO02), which focuses on building and simulating algorithms independently or coll

DOI:

aboratively to solve everyday problems using sequences, conditional selections, and repetitions. Similarly, for the 6th grade, competency (EF06CO02) mandates designing algorithms involving sequential, repetition, and selection instructions through a programming language.

Accordingly, this article describes a pedagogical experience that, in addition to teaching AI principles applied to sustainability and ethics, aims to promote a measurable shift in the ethical and sustainable perceptions of elementary school students. Through theoretical classes and hands-on projects using Scratch and Lego Mindstorms EV3, the curriculum allowed children to experiment with machine learning. This approach encouraged critical reflection on how technological innovations can be guided toward building a fairer, more sustainable, and ethically responsible future, while also illuminating both the limitations and capabilities of technology.

To guide this investigation, the study addresses the following central research question: "How can a project-based learning intervention combining block-based programming and robotics influence elementary school students' perceptions regarding AI ethics, accountability, and environmental sustainability?" The underlying hypothesis is that engaging children in practical AI activities helps them move away from viewing technology as a magic or autonomous entity, fostering a more realistic understanding of human responsibility and environmental application.

2. Theoretical Framework

In recent years, AI and Machine Learning have become transformative elements in education, enabling students of all ages and grade levels to develop essential 21st-century skills. According to Ludermir (2021), although the success of AI is undeniable and heavily impacts daily life, machines are still far from mastering many aspects of our world, which underscores the importance of introducing these discussions in the school environment at an early stage, as technological advancements demand that younger generations are prepared ethically and critically.

Furthermore, fostering engagement with AI and machine learning tools allows students to develop computational thinking, problem-solving skills, and critical awareness, all of which are indispensable for them to act as leading citizens in an increasingly digital society. Similarly, Fernandes et al. (2024) highlight that while AI offers unprecedented opportunities for personalized learning, administrative efficiency, and teaching support, it also poses significant challenges regarding ethics, privacy, algorithmic bias, and fairness. Therefore, for students to understand and act responsibly, pedagogical practices must promote equity and respect for differences, enabling AI to serve as a tool for inclusion and social justice rather than just automation.

To enable this complex, interdisciplinary education, Project-Based Learning (PBL) emerges as an ideal methodology, placing students at the cente r of the educational process and empowering them to drive their own search for knowledge. PBL stands out by fostering active and meaningful learning, connecting curriculum content to real-world challenges, and stimulating essential skills such as critical thinking, problem-solving, and collaboration, and in this regard, Santos et al. (2024) state that PBL offers significant benefits, including increased student engagement, the development of critical and creative skills, and the interdisciplinary integration of knowledge, representing a promising approach to improving the quality of Basic Education. Consequently, within the context of computing, PBL allows students to apply theoretical concepts to real projects, ensuring an active and meaningful learning experience.

Within this methodological framework, utilizing tangible tools like Lego Mindstorms EV3 acts as an incentive that materializes student learning. According to Pimentel et al. (2025), combining LEGO Mindstorms EV3 with active methodologies enhances not only technical competencies but also socio-emotional skills, including teamwork and communication, making the learning process more effective and meaningful, and thus, combining PBL with robotics fosters richer learning environments where students take the lead, stimulating contemporary skills like computational thinking alongside critical awareness, allowing them to build solutions that account for the sustainable and ethical impacts discussed in theory.

3. Method

This study is structured as an action research report with a qualitative approach, supplemented by descriptive quantitative data. The classes regarding this experience report took place during the Mandatory Supervised Internship IV course, part of the Teaching Degree in Computer Science program at the Federal Rural University of Pernambuco (UFRPE). The process began with the development of a course plan highlighting Project-Based Learning, which was the active methodology used throughout the entire practical component of the course.

3.1. Research Context

The entire course was conducted at the Technology in Education and Citizenship Unit (UTEC Gregório Bezerra), located in the Várzea neighborhood within the metropolitan region of Recife. The participants consisted of 11 elementary school children, aged 10 to 12 years old, comprising 4 girls and 7 boys.

Furthermore, during the diagnostic assessment, there was a surprise regarding the children's lack of familiarity with Scratch[1] and educational robotics, as only one child had previously used Lego Mindstorms and just three knew what Scratch was. In light of these obstacles, the course was adapte

[1] https://scratch.mit.edu/

d so that the classes maintained a standard three-hour duration, where the first part would be purely theoretical and the second part practical, alongside the use of Kahoot[2] to support content assimilation, totaling a 36-hour course delivered over 6 hours per week.

Kahoot is a gamified learning platform described by Owen and Licorish (2020) as a game-based learning environment designed to foster student engagement and motivation by leveraging three components of motivation theory, namely challenge, through competing with peers to answer questions, fantasy, by promoting absorption and involvement within the game, and curiosity, via sensory and cognitive stimulation. Singh, Mulyadi, and Ong (2024) complement this by stating that Kahoot is understood as a collaborative learning tool that allows educators to create quizzes, surveys, and discussions to assess student learning, knowledge, and engagement, adding that educators can utilize these quizzes to evaluate student understanding during classes, identify misconceptions, and adjust their teaching strategies accordingly.

3.2. Execution Stages

The course proceeded with an approach divided between theory and practice across 8 lessons, where students were introduced to the topics theoretically but were always encouraged to participate, either by answering questions raised during the explanation or by sharing their opinions on the subject. The flowchart in Figure 1 illustrates the complete structure of the course.

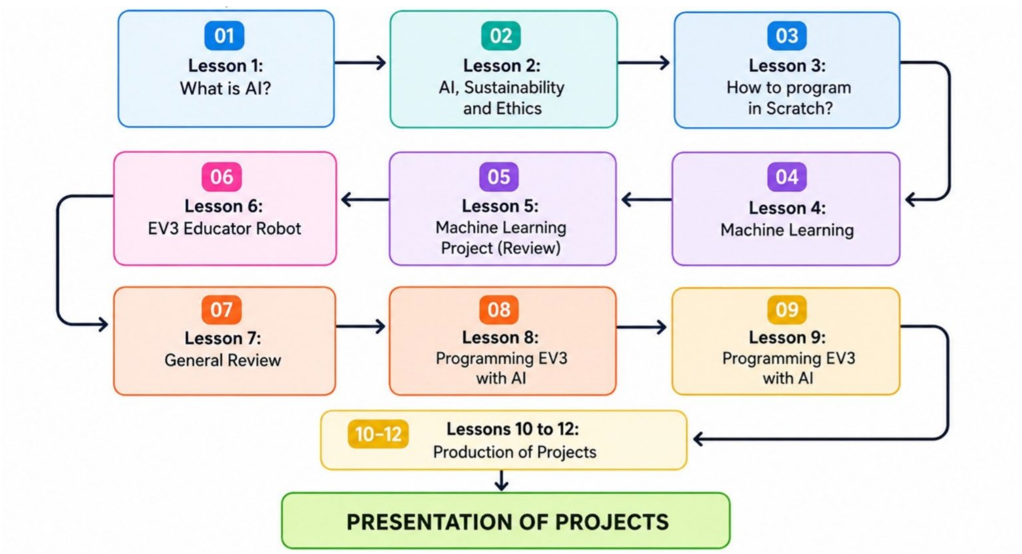

Figure 1 - Flowchart of the course structure

Following the theoretical part, students were encouraged to engage in practical activities through challenges that combined plugged or unplugged approaches, and near the end of these first 8 lessons, Kahoot was utilized a

[2] https://kahoot.com/pt-BR/

s a tool for content review, proving to be an effective way to reinforce learning among the students, who showed great engagement with the playful and interactive nature inherent to Kahoot.

Lesson 9 was reserved for students to further explore machine learning techniques and EV3 programming using Scratch. Ultimately, out of the 12 total lessons, two were dedicated to allowing students to produce two projects covering all topics presented in the course, and the final lesson was set aside for students to present their projects to the UTEC Gregório Bezerra community.

The use of slides during theoretical classes incorporated elements that interacted with the students rather than merely presenting content, as slides featuring questions aimed at the children transformed purely expository lessons into debates, encouraging active student participation. In the same manner, students were challenged throughout the entire course with ethical dilemmas, such as determining accountability in the event of an autonomous vehicle crash, a practice that fostered a closer connection between the interns and the children while enabling students to enhance cognitive and social competencies, including critical thinking, collaboration, and problem-solving.

The use of unplugged tools for certain practical challenges was also a contribution during the lessons, shifting students from the virtual world to the real one and demonstrating that computer science education can occur concurrently with computer usage. Furthermore, to enhance child engagement, a points system was implemented throughout the course, where each child earned points for class participation, attendance, Kahoot rankings, and project development during challenges, receiving as a reward the opportunity to grow a "participation tree" with leaves, flowers, or fruits. Figure 2 illustrates the interaction between the children and the interns and displays the participation tree at the conclusion of the course.

Figure 2 – Children interacting with teachers (left) and the participation tree (right)

It is important to mention that, as pointed in Section 3.1, the lack of familiarity with Scratch and educational robotics required Lessons 3 and 6 to focus directly on the specific type of programming needed for Lego Mindstorms, in the case of Scratch, and on the specific educator robot, in the case of Lego. This decision was made to accelerate the process given the short timeframe of the course, and therefore, during the Scratch lesson (Lesson 3), an introduction to the platform was presented, followed by an adaptation where the children used the Lego Mindstorms EV3 extension blocks within the platform, simulating the programming of the actual robot.

During the educator robot lesson (Lesson 6), the children were prompted to create simple programs for the robot to produce sound signals and perform movements, such as turning left and right, considering that the complete integration, combining block-based programming and machine learning, would only be executed in subsequent lessons.

Regarding the final course project, the class was divided into two groups of five, as one of the students left the course due to family reasons. The projects aimed at the ethical and sustainable use of AI, utilizing machine learning with Machine Learning for Kids, block-based programming, and Lego Mindstorms EV3. Following a brief discussion with the children, two projects were decided upon, one for each group: automatic recycling bins for selective collection of paper, plastic, glass, and metal, and a model of a sustainable farm. Figure 3 display the two projects and their respective groups during the presentation, though it is worth noting that some students were absent on the presentation day, and therefore the groups are not complete.

Figure 3 - Automatic Recycling Bin project (left) and Farm of the Future project (right)

In the first project, named by the children as Automatic Recycling Bin, students had to produce a system that, upon detecting the material via webcam, would automatically open the lid of the corresponding bin for disposal. The project utilized cardboard boxes, colored paper, string, and barbec ue skewers, resulting in a design built with simple and sustainable materials. For the second project, named by the children as Farm of the Future, students had to develop a system where, upon detecting that the plantation soil required water, an automated irrigation system would be activated solely on that plot of land. To achieve this, a styrofoam board was used to construct the farm model, along with modeling clay and popsicle sticks, also resulting in a project made from simple and sustainable materials.

It is important to emphasize that both projects utilized machine learning for the recognition of recyclable materials and the plantation soil, alongside the Lego EV3 for the automated components. Furthermore, all programming was conducted by the students within Scratch, in accordance with what had been covered throughout the course.

4. Results and Discussions

The data collected throughout the course provided valuable insights into the students' learning process and their engagement with the proposed methodologies, and to evaluate content retention and the effectiveness of the theoretical-practical approach, the results of the interactive quizzes applied at the end of the lessons were analyzed. Figure 4 presents a graph of the obtained results, displaying the percentage of correct answers by the students during the use of Kahoot.

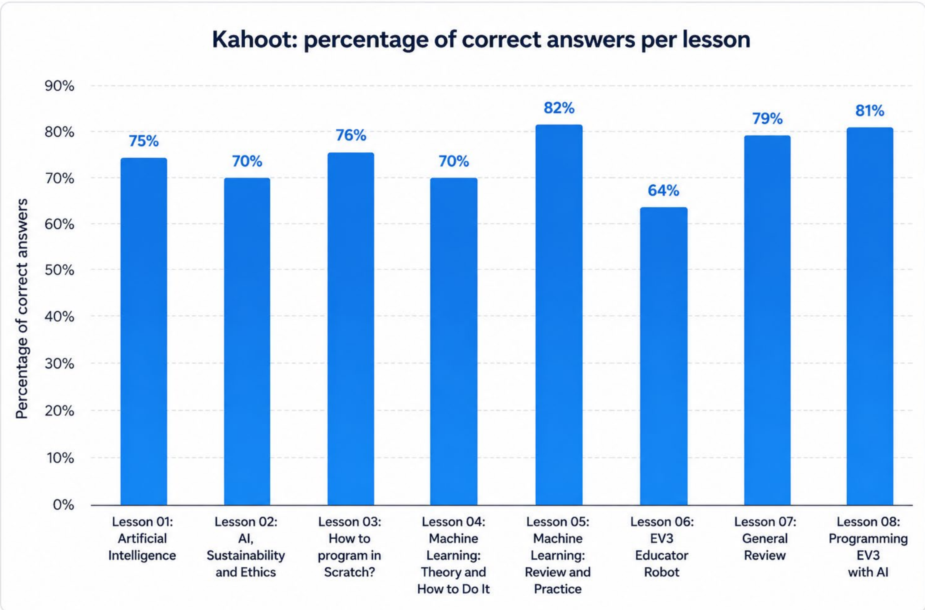

Figure 4 - Percentage of correct answers per lesson.

The data presented in the graph reveal high student achievement rates throughout the lessons, with correct answer percentages ranging between 64% and 82%. Lessons addressing specific topics such as "Artificial Intelligence" (75%), "AI, Sustainability, and Ethics" (70%), "How to Program in Scratch" (76%), and "Machine Learning: Theory and Practice" (70%) demonstrated ex cellent student performance, indicating an adequate assimilation of the presented content.

As can be observed, "Lesson 05: Machine Learning: Review and Practice" achieved the highest rate of correct answers (82%), suggesting that the structure of the previous lessons, divided between theory and practice, contributed to knowledge retention, which can be further confirmed by "Lesson 07: General Review", which obtained 79% of correct answers. On the other hand, "Lesson 06: EV3 Educator Robot" presented the most modest performance (64%), though we conclude that this percentage is due to the fact that it was the students' first experience with the EV3 educator robot, as mentioned in Section 3.1.

The use of Kahoot as a resource to review content proved efficient in increasing student motivation. The results shown in the graph of Figure 4 corroborate this statement, revealing that the systematic implementation of Kahoot throughout the eight lessons not only allowed for the continuous assessment of student assimilation but also fostered a motivating learning environment where concepts of AI, ethics, sustainability, and robotics could be effectively internalized. The application of the tool as a way to assess children's learning proved to be attractive and successful, while also bringing students and teachers closer together.

4.1. Pre- and Post-Test

In addition to Kahoot, a pre- and post-test was developed during the planning and structuring phase of the course to serve as a data collection method, aiming to verify whether there was an increase in students' perception regarding the subject. The pre- and post-test was constructed using a Likert scale, a measurement method utilized by researchers to evaluate people's opinions, attitudes, and understandings regarding a specific topic.

In total, the pre- and post-test consisted of 15 identical questions, each offering five options for the children to choose from, and to make the test more playful, emojis were used in the responses, with Figure 5 demonstrating how a question in the pre- and post-test was structured.


A inteligência artificial pode ser usada para melhorar a vida das pessoas e cuidar do planeta ao mesmo tempo. *

- Discordo Totalmente
- Discordo
- Não sei / Neutro
- Concordo
- Concordo Totalmente

Figure 5 – A pre- and post-test example question.

Scores were suppressed to avoid influencing the children during the test, with each alternative ranging from 1 to 5 points, such that the established standard was: Strongly Disagree = 1 point; Disagree = 2 points; Do not know / Neutral = 3 points; Agree = 4 points, and; Strongly Agree = 5 points, with the pre- and post-tests being administered during the first and final lessons, respectively.

During the tests, students encountered the following statements:

- [Q1] Artificial intelligence can be used to improve people's lives and take care of the planet at the same time;
- [Q2] Robots programmed with AI can help with tasks that reduce the waste of energy and natural resources;
- [Q3] I believe that learning to program robots can help me think of solutions to environmental problems;
- [Q4] The creation of new technologies must always take into account the impact they will have on nature;
- [Q5] It is possible to use AI to propose creative ideas that help reduce waste or pollution;
- [Q6] I feel capable of imagining how a robot could contribute to making my city more sustainable;
- [Q7] When we create technology, we need to think about the consequences for people;
- [Q8] Robots and artificial intelligence should only make important decisions when there is human supervision;
- [Q9] I can explain to a classmate how AI can be present in simple everyday things, like games and apps;
- [Q10] Small robot programming actions (such as saving energy or organizing materials) can generate major future changes;
- [Q11] The responsibility for what an AI does always belongs to the person who programmed it, not to the machine itself;
- [Q12] Using AI and robotics can help create fair and accessible solutions for different groups of people;
- [Q13] I believe that technology can be an ally in protecting nature and reducing environmental problems;

- [Q14] It is important for schools to encourage students to think about how AI can be used for the good of the planet;
- [Q15] I would like to learn more about how intelligent robots can help build a sustainable future.

It is important to clarify that during the application of the pre-test, 7 out of the 11 children were present, whereas during the post-test, 8 out of the 11 children were present, meaning that to prevent errors during data analysis, only the post-test results of the 7 children who had participated in the pre-test were accounted for, and Figure 6 displays the results of these pre- and post-tests.

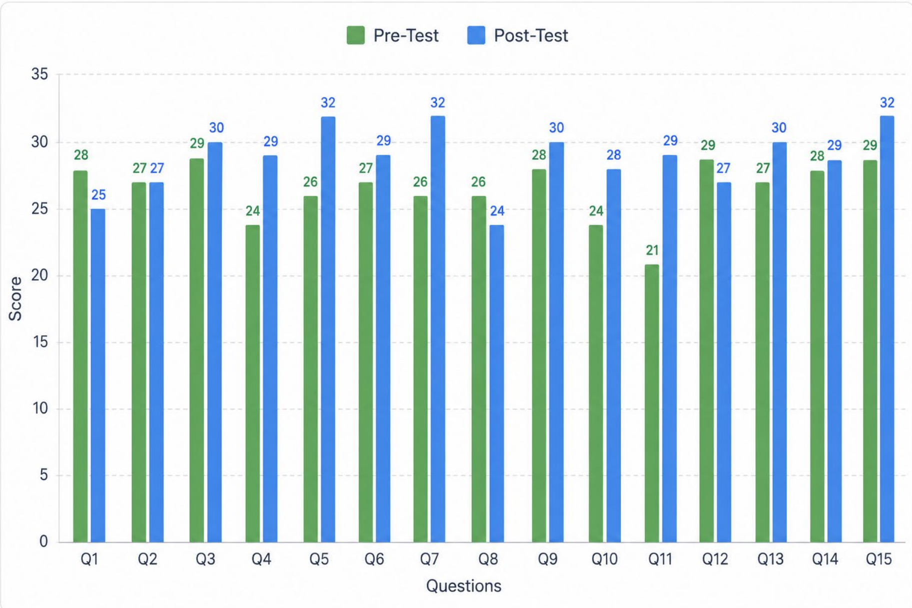

Figure 6. Pre- and Post-test results.

The numbers presented in Figure 6 represent the total number of points for each question, summing all students, where each question could reach a maximum of 35 points if all 7 students responded that they strongly agreed, and the maximum overall score the pre- or post-test could achieve equaled 525 points. In this manner, the pre-test obtained a result of 399 points, while the post-test obtained a result of 433 points, and to calculate the average, where the maximum average would be 5, the final results were divided by the total number of responses (7 students answering 15 questions = 105 responses), yielding a pre-test average of 3.8 and a post-test average of 4.12. This overall score movement from 3.8 to 4.12 suggests a positive trend within the group following the classes, pointing toward an evolving perception of artificial intelligence and robotics and a gradual articulation of concepts that may have previously been uncertain or intuitive.

The largest increases observed were regarding authorship and responsibility behind technology, with the most visible growth occurring in statement [Q11], concerning how responsibility for what an AI does always belongs t o its programmer rather than the machine, since in the pre-test, students seemed unable to determine accountability if something went wrong, whereas the post-test suggest that the class began to perceive AI less as an autonomous entity and more as a human-directed system. Similarly, in statement [Q7], regarding the need to think about consequences for people when creating technology, the children appeared to develop a technological empathy, as the 32 points out of a maximum of 35 suggest a near-consensus among the students, indicating an alignment between technological innovation and human well-being.

Two other questions that showed relevant increases, both related to sustainability, were statements [Q4], regarding how the creation of new technologies must always consider environmental impact, and [Q5], concerning the possibility of using AI to propose creative ideas to reduce waste or pollution, where [Q4] suggests that students began to view environmental protection as a prerequisite for technological development rather than something merely optional. In the same vein, statement [Q5] reached a near-consensus among the group, and what might have previously seemed abstract appeared to become more tangible through the practical activities and projects developed throughout the course, pointing toward the potential of AI to address real-world problems such as waste management.

Curiously, there were points where the average declined, yet this is not inherently negative, as it may indicate the development of critical thinking among the students. An example of this is statement [Q1], regarding whether artificial intelligence can be used to improve people's lives and take care of the planet simultaneously, where it is possible that, after the classes, students adopted a more cautious stance, recognizing that maintaining a balance between human progress and environmental care is a complex challenge involving difficult choices. Similarly, statement [Q12], concerning how using AI and robotics can help create fair and accessible solutions for different groups of people, can be understood as a direct reflection on how AI can reproduce biases, a topic covered during the classes that may have influenced students to become more cautious in asserting that technology is always fair.

Regarding statement [Q8], which posits that robots and artificial intelligence should only make important decisions under human supervision, one possibility is that after seeing in practice that AI is efficient and useful when solving problems, students may have decreased their perception of danger and the need for constant human vigilance, and taking into account the substantial increase seen in [Q11], students may have replaced the idea of vigilance with responsibility in programming.

Finally, an interview was conducted with the children regarding their perceptions of the course, and as they are elementary school students, they will be referred to only by the initials of their names. When asked about their thoughts on the course as a whole, W.T. expressed that "it was perfect

," while S.C. mentioned that "the instructors explain well. Since you explain well, you clarified things that we didn't even know, understand, or know how to do... you explained it and then I knew how to do it." When questioned whether they would like to learn more about technology, I.C. stated: "if there is a course next year, I will participate." Regarding what they enjoyed most, W.T. highlighted "learning... having the experience and carrying it into the future." Furthermore, S.L. noted that "the most interesting part for me was programming the robot," while E.G. added: "I also really liked Scratch." For E.M., "the course for me was perfect," and L. concluded: "I wished this course would not end."

5. Final Considerations

This paper sought to report how complex themes such as AI, sustainability, and ethics can be introduced to and experienced by elementary school students, bringing machine learning principles into the classroom to encourage them to reflect critically toward a fairer, more sustainable, and ethical future. This pedagogical experience demonstrated a way that by combining playful tools like Scratch and Lego Mindstorms EV3 with Project-Based Learning, it was possible to engage children's curiosity, introducing technical concepts and fostering discussions on social responsibility.

The results offer encouraging preliminary indicators regarding shifts in students' perceptions. For instance, the marked increase in the responsibility question [Q11] suggests that the course contributed to demystifying technology, helping participating students begin to view AI less as an autonomous entity and more as a human-made tool whose outcomes depend on its creators.

In the same vein, fluctuations observed between the pre- and post-test, such as the decreased demand for human supervision shown in statement [Q8], may point to an evolving sense of technical confidence. Within the scope of the course, children appeared to recognize that a well-programmed AI does not necessarily require constant human oversight, highlighting the importance of continuous educational debates that balance trust in programming efficiency with ethical decision-making.

The qualitative evaluation, comprising the Kahoot quizzes and interview testimonials, highlights the motivational engagement during the activities, as visually reflected in the high performance on the quizzes. Additionally, despite initial unfamiliarity with the tools, students demonstrated adaptable learning that culminated in the execution of the Automatic Recycling Bin and Farm of the Future projects.

However, given the exploratory nature of this study, methodological limitations must be acknowledged when interpreting these outcomes. The sample size was small, consisting of 11 elementary school children, with complete paired pre- and post-test data available for only 7 participants. Also, the evaluation instrument was non-standardized and designed specifically for this workshop, lacking prior empirical validation and the study was conducted without a control or comparison group. Consequently, these findings reflect trends limited to this specific group and setting, and cannot be generalized across broader demographic or educational contexts.

It is concluded, therefore, that despite these methodological constraints, this exploratory study provides valuable qualitative insights and practical foundations for introducing complex AI and ethics concepts into primary education. The trends observed within this cohort demonstrate promising pathways for empowering children as critical designers of technology rather than passive consumers. Future research can build upon these preliminary findings by applying validated instruments, expanding the sample size across diverse educational contexts, and incorporating control groups to more rigorously evaluate the long-term impact of such pedagogical interventions.

Acknowledgements

We would like to express our deepest gratitude to UTEC Gregório Bezerra, under the coordination of Maria do Carmo de Lima, for welcoming us so warmly and providing the necessary equipment for the execution of our project. The full cooperation of the UTEC Gregório Bezerra team was crucial to the success of our activity, as they provided a welcoming space for both students and instructors, while ensuring the interns had access to all the resources required to carry out the project and to the National Council for Scientific and Technological Development (CNPq) Universal Call for Proposals 2023 (404916/2023-6).

References

AKGUN, Selin; GREENHOW, Christine. Artificial intelligence in education: Addressing ethical challenges in K-12 settings. *AI and Ethics*, v. 2, n. 3, p. 431-440, 2022.

DABBAGH, Hossein et al. AI ethics should be mandatory for schoolchildren. *AI and Ethics*, v. 5, n. 1, p. 87-92, 2025.

FERNANDES, Allysson Barbosa et al. A ética no uso de inteligência artificial na educação: implicações para professores e estudantes. *Revista Ibero-Americana de Humanidades, Ciências e Educação*, v. 10, n. 3, p. 346-361, 2024.

KORKMAZ, Özgen. The effect of scratch-and lego mindstorms Ev3-Based programming activities on academic achievement, problem-solving skills and logical-mathematical thinking skills of students. *MOJES: Malaysian Online Journal of Educational Sciences*, v. 4, n. 3, p. 73-88, 2016.

LUDERMIR, Teresa Bernarda. Inteligência Artificial e Aprendizado de Máquina: estado atual e tendências. *Estudos avançados*, v. 35, p. 85-94, 2021.

OWEN, Helen E.; LICORISH, Sherlock A. Game-based student response system: The effectiveness of Kahoot! on junior and senior information science students' learning. *Journal of Information Technology Education: Research*, v. 19, p. 511-553, 2020.

PIMENTEL, Henrique Pablo PS et al. Robótica Educacional com LEGO Mindstorms EV3: Uma Abordagem Ativa para o Ensino de Lógica de Programação. In: *Workshop sobre Educação em Computação (WEI)*. SBC, 2025. p. 330-340.

SANTOS, Soraia Stabach Ribas Ferrari et al. Aprendizagem baseada em projetos na educação básica: revisão sistemática da literatura. *Caderno Pedagógico*, v. 21, n. 3, p. e3395-e3395, 2024.

SINGH, Charanjit Kaur Swaran; MULYADI, Dodi; ONG, Eng Tek. Exploring the use of Kahoot! to monitor learning performance among students in higher education. *Training, Language and Culture*, v. 8, n. 4, p. 36-47, 2024.

WANGENHEIM, Christiane Gresse Von; NUNES, Vinícius Rodrigues; DOS SANTOS, Giovane Daniel. Ensino de Computação com SCRATCH no Ensino Fundamental-Um Estudo de Caso. *Revista Brasileira de Informática na Educação*, v. 22, n. 3, p. 115-125, 2014.