Demystifying Artificial Intelligence in Elementary Education: A Practical Approach with Robotics and Machine Learning

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Abstract: The global transition to the so-called Society 5.0 defines a new paradigm in civilization, where AI shifts from a niche technology to an omnipresent component of daily life, and this widespread use demands a new core competency: AI literacy. In this context, this study proposes and analyzes an introductory course in Artificial Intelligence and Robotics for 5th-grade elementary school students, centered on the use of simplified Machine Learning interfaces, such as Teachable Machine, integrated with Scratch and LEGO EV3 Educational Robotics. To this end, qualitative semi-structured interviews were conducted before and after the course to measure the evolution in the understanding of fundamental AI concepts, comparing the students' prior knowledge with that acquired after the intervention. The results indicate that while difficulties in the theoretical definition of AI persist, there was significant progress in understanding its daily applications and technical functioning. The main finding demonstrates that hands-on practice with robotics demystified AI as a "black box," leading students to understand that system effectiveness directly depends on human data curation and ethical training.

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

1. Introduction

The global transition to the so-called Society 5.0 defines a new paradigm in civilization, in which technological innovation not only optimizes industrial processes but is integrated in a human-centric manner to solve complex social challenges and enhance citizens' well-being. In this era, AI shifts from a niche technology to an omnipresent component of daily life, influencing everything from personalized medical diagnoses to vehicle automation, a ubiquity that demands a new core competency: AI literacy. This literacy is not restricted to the ability to operate advanced software, but enco mpasses an ethical, critical, and functional understanding of the basic principles of AI, thereby enabling individuals from an early age to act not as mere passive consumers, but as active citizens aware of its limitations and potentials (JAPAN, 2015; MILLS et al., 2024).

Traditionally, Educational Robotics has served as a fundamental pillar in developing computational thinking and STEM (Science, Technology, Engineering, and Mathematics) skills in Elementary Education, providing a practical and tangible platform for applying programming and logic concepts (ROGERS; PORTSMORE, 2004). However, in the contemporary context, the integration of robotics and AI becomes essential, consequently requiring projects to evolve from mere logical sequences to systems capable of making decisions based on data and Machine Learning (ML).

It is at this intersection that a crucial challenge for Elementary Education lies, as most AI and Machine Learning concepts are perceived as excessively abstract and technically complex for this age group. This complexity creates an imminent risk that students may fail to comprehend the basic assumptions and algorithms of the technology, a difficulty that requires the use of age-appropriate tools and pedagogies to build a solid conceptual understanding (MELSION et al., 2021 apud YIM; SU, 2025). Since this gap hinders the formation of an early knowledge base, the development of accessible methodologies that translate the abstract into the concrete and demystify AI has become highly urgent.

To address this obstacle and advance the demystification of the subject, this action-research study proposes and analyzes a practical approach designed for 5th-grade elementary school students. The proposal centers on the development, execution, and evaluation of a course that utilizes simplified Machine Learning interfaces, such as Teachable Machine, integrated with Scratch and Educational Robotics with LEGO EV3, thereby making abstract concepts tangible through actions in the physical world. The primary objective is to evaluate the effectiveness of this methodology by measuring the evolution in the understanding of fundamental AI concepts, which allows for comparing the students' prior knowledge with that acquired after the intervention.

2. Theoretical Framework

Understanding how elementary school students conceptualize AI is essential for developing effective pedagogical practices, especially since Heeg and Avraamidou (2026) point out that, although 11- and 12-year-old children already possess general notions about AI, frequently associated with voice assistants and recommendation algorithms, this understanding tends to be anthropomorphized and lacks technical depth.

To overcome this superficiality, Educational Robotics presents itself as a practical field that materializes both classical and contemporary learning theories, a role that, as Dalaqua (2025) analyzes, revives Piaget's c onstructivism, in which learning occurs through active interaction and the continuous assimilation and accommodation of concepts during problem-solving. Simultaneously, this practice aligns with Papert’ s constructionism, which argues that knowledge construction is more effective when students create tangible, meaningful artifacts (PAPERT, 1980; DALAQUA, 2025). In addition to the individual cognitive aspect, robotics favors Vygotsky’ s socio-interactionism, given that collaboration on projects allows students to operate within their Zones of Proximal Development (ZPD), where interaction with peers and mediators facilitates the understanding of complex concepts that could not be achieved individually (VYGOTSKY, 1978; DALAQUA, 2025).

Also, in light of the demands of Society 5.0, the traditional transmissive teaching model proves to be insufficient, a scenario in which Project-Based Learning (PBL) positions the student as the protagonist by challenging them to solve real, complex problems (SILVA et al., 2024). Although popularized by Kilpatrick and grounded in John Dewey’ s early 20th-century philosophy of "learning by doing", PBL gains renewed relevance today by promoting interdisciplinarity and critical thinking (PASCON; PERES, 2023). PBL dialogues directly with Freirean pedagogy and Vygotskian theory by utilizing concrete reality and problem-posing as the drivers of learning, an integration that Nascimento and Paim (2022) highlight by showing that, much like in Paulo Freire’ s popular education, PBL awakens curiosity and autonomy.

Furthermore, this joint problem-solving reflects the socio-interactionist principle that human beings are constituted through relationships with others and with culture, thereby validating the collective construction of knowledge based on real-world contexts. While the integration of Robotics and PBL enhances STEAM (Science, Technology, Engineering, Arts, and Mathematics) education and fosters a holistic, creative formation (VASCONCELOS et al., 2025), the current technological landscape demands a step further: AI literacy. Martins (2024) argues that familiarity with Machine Learning concepts must occur as early as Basic Education to guarantee the social and economic participation of future citizens, a necessity supported by global initiatives, such as the AI4K12 project, which demonstrate that students in this age group are capable of understanding the fundamentals of neural networks and AI ethics, provided these topics are addressed appropriately (MARTINS, 2024).

Consequently, the union of Machine Learning tools with the tangibility of robotics creates a propitious environment for demystifying the "black box" of Artificial Intelligence, ultimately shaping not merely users, but conscious creators of technology.

3. Method

This work was developed based on the activities carried out during an introductory course on Artificial Intelligence and Robotics, which was conducted as part of the Mandatory Supervised Curricular Internship 4 of the Te aching Degree in Computer Science at the Federal Rural University of Pernambuco (UFRPE).

The intervention took place at UTEC Jardim Botânico, located in the city of Recife, Pernambuco, spanning from September 2025 to November 2025, and involved seven 5th-grade elementary school students who came from municipal schools surrounding the UTEC facility. The selection of these participants was mediated through a partnership with the UTEC management team, which was responsible for promoting the course and organizing registration, subsequently providing the list of enrolled students and ensuring the required parental consent.

The methodological execution of this research is structured into three consecutive and interdependent phases, beginning with the Course Planning stage, which establishes the foundational design, followed by the Course Execution phase, where the pedagogical intervention is implemented in practice, and culminating in the Data Analysis stage, where the collected qualitative insights are systematically evaluated.

3.1. Course Planning

The course planning followed a sequential and progressive approach distributed across eleven in-person sessions, totaling 33 class hours, all of which were conducted at UTEC Jardim Botânico along with the utilization of all the robotics materials employed throughout the program. Furthermore, the curriculum was structured into four distinct modules, namely: "What is Artificial Intelligence?", "Machine Learning with Teachable Machine", "Building with Scratch", and "Robotics and Artificial Intelligence with LEGO EV3", and Table 1 presents a comprehensive summary of the classes taught during the course.

Table 1 - Curricular structure and pedagogical goals of the course.

Class	Description
Module 1: What is Artificial Intelligence?	
1	Presentation of the tools, course objectives, and administration of the initial assessment, followed by an introduction of Artificial Intelligence.
2	Explanation of how machines "learn" through pattern recognition and the fundamental importance of data for their training.
3	Simulation of a Classifier, introducing the conceptual foundations of Classifiers.

Module 2: Machine Learning with Teachable Machine	
4	Hands-on training of a Machine Learning model to classify images using the Teachable Machine platform.
5	Hands-on training of a Machine Learning model to classify sounds using the Teachable Machine platform.
Module 3: Building with Scratch	
6	Initial introduction to Scratch and the Teachable Machine extension, where students engage in a practical application utilizing the sound model developed.
7	Construction of a game in Scratch that integrates the image classification model.
Module 4: Robotics and Artificial Intelligence with LEGO EV3	
8	Introduction to LEGO EV3, focusing on its components and communication with Scratch.
9	Integration of LEGO EV3 with Teachable Machine and Scratch to execute physical movements triggered by voice and image recognition.
10	Project execution.
11	Final project presentation and conducting the post-course interviews.

As seen in Table 1, the course planning encompassed moments of conceptual introduction, hands-on experimentation, collaborative creation, and assessment through interviews at both the beginning and the end of the program. This intervention began with diagnostic and familiarization activities, which were followed by the construction and development of training models and their execution, along with the implementation of both plugged and unplugged activities, and ultimately culminated in the presentation of the final project.

Furthermore, the structuring of the course into four modules followed a pedagogical logic of progressive complexity and scaffolding, starting with fundamental theoretical concepts in Module 1 to level the students' prior knowledge. Following this initial stage, the software was introduced in isolation throughout Modules 2 and 3 to focus specifically on programming logic and model training without the interference of physical variables, and it was only in Module 4 that the hardware component was integrated. At this po int, the students had already learned the underlying logic of AI, thereby allowing them to focus entirely on the challenges of interacting with the physical world, a sequence designed specifically to avoid cognitive overload and ensure that the conceptual foundation was solid before moving on to complex practical applications.

3.2. Course Execution

Considering the nature of the course, various teaching resources were employed to facilitate learning, which included the use of a projector for presentations and providing students with access to computers for interacting with digital platforms. These digital resources encompassed Scratch, sourced from the RAISE Playground platform for block-based programming, and Teachable Machine, a Google tool designed to simplify and ease access to Machine Learning through a highly user-friendly interface. Furthermore, the manipulation of two LEGO EV3 kits complemented the main set of resources, and in specific sessions, the utilization of materials such as A4 paper, markers, whiteboards, colored tape, and pencils proved essential for conducting unplugged activities, which are defined as tasks that do not require technological tools for their execution.

For the development of the activities and the initial introduction to machine training, Teachable Machine was utilized, a web-based digital tool through which students could collect data, train, and test their own custom classifiers by focusing specifically on the image and sound modalities available on the platform. The user-friendly nature of this interface proved essential in facilitating the data collection, training, and testing phases of the classification models by the students.

To execute and control the created models, the study employed the RAISE Playground, a block-based programming platform developed by MIT, which, as an adaptation of Scratch featuring extensions for Artificial Intelligence and robotics, offered a familiar environment to the students while allowing the import of image and sound models via URL. Consequently, this integration enabled the application of these models within logical conditionals, effectively translating the recognition performed by the AI, such as identifying an object or a voice command, into concrete actions within the algorithms.

The integration cycle between Artificial Intelligence and robotics was completed through the use of LEGO MINDSTORMS EV3 kits, which, comprising motors, sensors, and structural assembly parts, served as the primary physical environment for applying the developed skills. Through the extension that connects Scratch with the EV3 hardware, the constructed robots were able to execute real-world actions based on voice commands and digitally processed image classifications, ultimately materializing the learning experience into a physical project.

3.3. Data Analysis

Semi-structured interviews were conducted with the students participating in the action research both before the start of the course, on the first day of class, and upon its completion, on the final day. Given their qualitative nature, these interviews did not follow a rigid order of questions, meaning that while the inquiries maintained a logical sequence, new prompts were dynamically incorporated as the students' reasoning flowed naturally.

Overall, the questions sought to elicit the students' prior knowledge regarding the following themes related to Artificial Intelligence: [Q1] What is Artificial Intelligence?; [Q2] Where is Artificial Intelligence found and what are its examples of use?; [Q3] How does Artificial Intelligence work?; [Q4] Are there "cognitive" similarities or differences (regarding intelligence and learning) between AI and humans?; [Q5] How does "learning" occur within Artificial Intelligence?; [Q6] Does Artificial Intelligence pose a danger to humanity?; and [Q7] How is an Artificial Intelligence created?

These exact same questions were posed at the end of the course, once again without a rigid order, which allowed the interview to resemble an informal conversation in the same manner as the initial sessions. The underlying intent of this action research was precisely to discern whether any significant changes occurred following the lectures and practical sessions on Artificial Intelligence, considering that the students had been introduced to foundational concepts such as AI, neural networks, machine vision, machine learning, and data training, in addition to observing these concepts operating in practice through the tools described in Section 3.2 of this paper.

4. Results and Discussions

The first stage of the course was dedicated to conceptual foundation and familiarization, aiming to level the students' prior knowledge before moving on to practical application. This first module, titled "What is Artificial Intelligence?", spanned from Class 1 to Class 3, during which the theoretical approach to pattern recognition prepared the students for the hands-on activity "AI for Oceans" by Code.org. More than a simple classification game between "fish" and "trash," this activity, illustrated in Figure 1, served as a reflective tool for students to confront algorithmic bias, given that by defining subjective criteria for training, they realized that AI is not neutral but rather reflects the choices and opinions of those who train it.

Figure 1 - Student practicing the “AI for Oceans” activity from Code.org.

The second stage, encompassing Modules 2 and 3, marked the transition from theory to practice, helping to demystify the functioning of the algorithmic "black box." By utilizing Teachable Machine, the students created their own databases from drawings, as shown in Figure 2, a process that demonstrated how machine learning is directly tied to the data provided, thereby positioning the student in an active role regarding model construction.

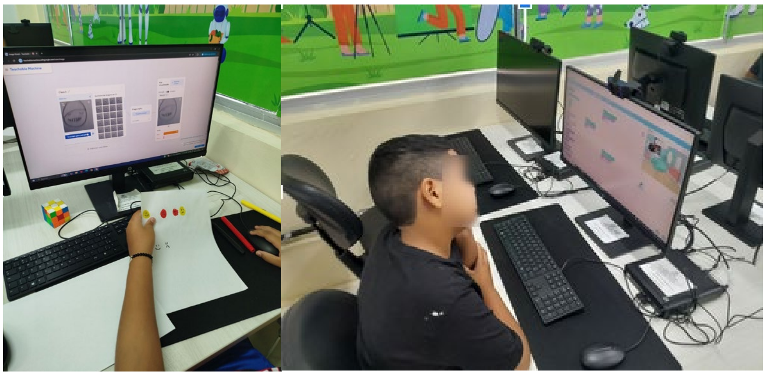

Figure 2 - Data training with Teachable Machine (left) and integration with Scratch (right).

Subsequently, the integration with Scratch rendered the concepts more concrete, allowing the children to visualize the underlying logic of AI as they watched a digital sprite react to their facial expressions, which ultimately provided a practical understanding of how the system interprets and reacts to the real world.

The third and final part of the course corresponded to Module 4: “Robotics and Artificial Intelligence with LEGO EV3,” which represented the culmination of the knowledge acquired in previous sessions. In this phase, students were introduced to LEGO EV3 in Class 8 and executed the integration between software and hardware in Class 9, enabling the robot to perform physical movements triggered by voice and image recognition processed via Teachable Machine and Scratch (Figure 3). Ultimately, this culminated in the final project execution, where the students, split into two groups, developed a voice-command automated wheelchair using LEGO EV3, applying all the AI classification concepts into a tangible artifact, whereas the module concluded with the project's implementation in Class 10 and its final presentation in Class 11, accompanied by the post-course evaluation interviews.

Figure 3 - Students handling the LEGO EV3 kit and conducting training in Teachable Machine.

A highlight regarding the teaching delivery was the high level of student engagement throughout the course. As observed by the student teachers, the introduction of plugged activities marked a significant shift in classroom dynamics, resulting in a notable increase in student interaction. This interest became even more evident during the LEGO EV3 module, where the opportunity to manipulate robotics kits and construct physical artifacts expanded the students' participation and enthusiasm toward the content.

Regarding the data analysis process, a qualitative content analysis approach was adopted, through which the students' knowledge and perceptions were mapped and organized into seven distinct thematic categories, as outlined in Table 2.

Table 2. Thematic categories for the qualitative analysis of interviews.

Code	Thematic Category
T1	Definition of Artificial Intelligence (Concept)
T2	Ubiquity of AI and its Practical Applications
T3	Underlying Mechanics and Functioning of AI
T4	Cognitive Superiority: AI versus Humans

T5	Comparative Learning Dynamics: AI versus Human Capacity
T6	Risks, Perils, and Ethical Implications in AI Usage
T7	Development and Creation Processes of AI Systems

By comparing the pre- and post-course interviews in light of the categories defined in Table 2, several critical insights regarding the students' conceptual evolution were identified. Regarding T1, no significant conceptual shift was observed, primarily because the students exhibited a foundational deficit regarding digital culture and world concepts, this baseline limitation rendered the conceptualization of AI highly abstract, as they struggled to grasp how more fundamental aspects of digital technology, such as internet protocols, databases, and servers operate. Conversely, a substantial shift in perception occurred within T2, where post-course interviews revealed a marked increase in both the quantity and diversity of AI-driven devices and functionalities recognized by the participants.

A similarly significant transformation was recorded in T3, as the combination of theoretical lessons and hands-on project development effectively demystified AI operations, allowing students to grasp the critical necessity of data acquisition, algorithmic training, and proper data curation to achieve satisfactory outcomes. Interestingly, student perceptions concerning T4 remained largely unchanged, despite acknowledging AI as a human creation, the participants still perceived it as nearly infallible, an idea reinforced by its ability to translate text, respond across multiple languages, generate animated videos, drive autonomously, and provide answers on virtually any topic.

In spite of this perceived infallibility, T5 demonstrated a nuanced and significant shift, since the students, while still considering AI powerful, began to comprehend its stark limitations when compared to human capabilities, specifically recognizing that machines lack the creativity and biological factors that are abundant in humans.

Furthermore, T6 revealed a critical evolution in risk awareness: initially, students held sci-fi-inspired notions that AI would reach a level of perfection enabling it to surpass humans in every aspect, whereas the post-interviews highlighted an understanding of real-world dangers, such as algorithmic data bias and the environmental footprint caused by the massive energy and resource consumption required to maintain these systems, alongside the realization that AI demands rigorous training to prevent critical errors.

Finally, T7 showed a modest shift in perception because, despite the persistent difficulties in abstract conceptualization noted in T1, the students successfully assimilated specific classroom concepts, such as machine v

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ision and neural networks, thereby enhancing their understanding of the technical requirements necessary to develop an Artificial Intelligence system.

It can be concluded that the primary cognitive shift observed in the post-course interviews lies in the demystification of the autonomous and superior capability of artificial intelligence, a phenomenon evidenced by the duality between T4 and T5, as well as by the increase in technical knowledge identified within T3 and T7.

The belief in AI as a superior entity, or as being "smarter than us," decreases within T4 and T5, whereas the acquired technical knowledge, demonstrated in T3 and T7, helped replace a "magical" view of artificial intelligence, reinforcing that its performance is directly linked to its programming and is, therefore, dependent on human action. In the pre-course interviews, statements such as "artificial intelligence is smarter than us because it knows how to create more things" were common among the students. However, this perception shifted in the post-course interviews toward reflections such as "artificial intelligence will not have the creativity that humans have," "we think because we have a brain, and AIs do not have a brain," and "it [AI] cannot have a feeling."

Consequently, these results highlight a clear demystification of artificial intelligence concepts following the instructional intervention. The initial, almost magical view of AI, where students verbalized that the technology was "smarter" than humans, shifted toward biological and psychic arguments, such as human brain capacity, emotions, and creativity. Furthermore, the perception of AI autonomy diminished as students recognized the necessity of human intervention in data selection and training to solve specific problems, ultimately reinforcing the central role of the human being throughout the entire process.

5. Final Considerations

In this action research, we conclude that there was a significant shift in the students' perception of artificial intelligence, as evidenced by the analysis of the qualitative, semi-structured interviews conducted before and after the course. Although certain concepts remained abstract for the students, as observed in some themes that emerged during the interviews, such as the core definition of AI and the machine's perceived "cognitive superiority" over humans, we believe this is due to several factors.

Among these are the students' developmental stage in grasping complex technological concepts, a baseline deficit in foundational concepts that would typically be acquired through Digital Culture and Digital World curricula (for instance, some participants struggled to understand how the internet functions or the difference between a webpage and a desktop application), and the fact that the term "artificial intelligence" itself inherently causes confusion for laypersons of any age group. Nevertheless, these conceptual hurdles did not impede the understanding of the concepts presented in the classroom, much less when the sessions transitioned to practical and playful activities.

Given the nature of this action research, there are some methodological limitations that must be acknowledged when interpreting the results: The study examined a small sample consisting of seven elementary school students, the intervention was conducted without a control group and the evaluation relied on qualitative semi-structured interviews designed specifically for this pedagogical context rather than standardized empirical instruments. Therefore, while the qualitative content analysis highlights a clear demystification of AI concepts, these findings reflect contextual, localized trends within this specific group, requiring caution before generalizing the results to broader educational settings.

Ultimately, these findings underscore the pressing need to integrate Artificial Intelligence education into Basic Education. It is essential to adopt pedagogical practices that move beyond the mere usage of digital tools, striving instead to demonstrate how the technology operates internally. By opening this "black box", we can deconstruct the pervasive view of AI as a mysterious form of "magic", and consequently, this approach fosters more critical citizens who do not simply consume technology but are fully capable of understanding and questioning the algorithmic systems present in their daily lives.

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