Empowering Young Minds:
A Comprehensive AI Education Framework for 4-5-Year-Olds

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Abstract
Children in the early years of schooling grow up in a world where Artificial Intelligence (AI) is ubiquitous and taken for granted in everyday life. However, the international literature lacks references to the potential of integrating educational AI applications for this age group. This gap underscores the urgency of our research. In this research paper, we present a novel pilot educational program that introduces AI concepts, applications, advantages, weaknesses, challenges, and risks in the daily lives of young school children in a simple, understandable, and consistent manner. With its potential to revolutionise early childhood education, this program fills a crucial gap. In the work context, we present the structure of the educational program, the tools, and how it is implemented in the classroom, and we draw initial quantitative conclusions about its effectiveness.

Keywords: Preschool Age, Artificial Intelligence, Machine Learning, Educational Program

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Introduction

Artificial Intelligence (AI) has become an integral part of modern life, influencing various aspects often without our immediate awareness. From personalised content suggestions on streaming platforms to voice-activated virtual assistants that aid in daily task management, AI applications are woven into the fabric of our daily lives. AI is present in smartphones, cars, workplaces, and home environments, driving innovation and significantly altering how we interact with the world. Moreover, AI is not a static concept but a highly adaptable and constantly evolving technology, always ready to meet new challenges and needs. This reassures us about its relevance and applicability in our lives (Gibson et al., 2023; Long & Magerko, 2020).

While limited studies focus on preschool and early childhood education, researchers have begun to identify the myriad ways AI applications can be used in educational settings. These include facilitating school administrative needs, analysing student performance, enhancing learning through intelligent teaching systems—especially in special education—utilising chatbots for language teaching and incorporating robotics with AI algorithms in STEM (Science et al.) classes. The potential of AI in early childhood education is vast and promising, offering new avenues for personalised learning and student support. We aim to explore and harness this potential in our pilot program, paving the way for a more optimistic future of education.

Introducing STEM in Kindergarten creates an environment conducive to children's development. Through STEM, children can explore the world, develop essential skills, and foster a passion for education and knowledge. These activities encourage creativity, innovation, and collaboration (Chesloff, 2013). Early childhood education is rapidly evolving due to extensive research on how children learn. According to Morrison et al. (2009), STEM programs can be effectively implemented in kindergarten. This is supported by recent brain development studies suggesting that starting STEM education in kindergarten can lead to positive future outcomes (Torres-Crespo et al., 2014). Furthermore, children's attitudes toward scientific concepts and knowledge are primarily formed in their early years. Research by Archer et al. (2010) indicates that these attitudes are difficult to change once children become teenagers. Katz (2010) also emphasises the importance of involving children in research activities before they start school, encouraging them to ask questions, collect data, and present findings under the guidance of specialised educators for a rich educational experience.

This paper investigates whether preschool-aged children can understand the possibilities and limitations of AI applications through programming and training robots. Despite their lack of technical background, this posed an exciting challenge, transforming theoretical research into a structured program for integration into the school curriculum. Initially, there was uncertainty about how children would respond, but it was essential to remember that this generation is growing up using smart devices. Young children often believe many things happen magically or inherently, so it was crucial to help them understand that these are not living beings with consciousness but machines that can achieve desired outcomes through proper programming and, in some cases, make strategic decisions. This study aims to examine:

- Whether children understood AI after participating in relevant activities.
- If this program can be integrated into the general Kindergarten curriculum after implementation.

Before conducting this study, we explored the importance of AI literacy and preschool-aged children's existing knowledge about AI.

Theoretical Background

AI Literacy

The concept of AI literacy was first introduced by Kandlhofer et al., who described it as the ability to understand the basic principles of AI (Kandlhofer et al., 2016). Later, Long and Magerko expanded this definition to include the skills needed to evaluate, communicate, and interact with AI responsibly and effectively (Long et al., 2020). As AI systems increasingly impact society socially, economically, and politically, understanding how they work has become essential. This includes knowing how AI systems perceive their environment, process data, and make decisions.

Given AI's significant role today, children must learn about AI, as they will encounter it both in their school years and throughout their adult lives. Additionally, understanding the technical aspects of AI is vital. By learning how AI collects and processes data and how these data influence decisions, children can dispel the common misconception that AI is an omniscient and infallible force. Experts believe this knowledge is essential to developing a more informed and critical perspective on AI.

Pre-existing Knowledge

Children live in an environment increasingly dominated by AI and spend significant time using applications that incorporate it. Research indicates that parental attitudes, socioeconomic levels, and cultural differences significantly influence how children perceive AI applications (Druga et al., 2018). Several studies explore how children learn about AI through interactions with pre-trained models or by training models themselves.

Vartiainen et al. found that children aged 3-9 understand the relationship between physical expressions and the outcomes of an interactive image prediction tool, actively engaging in the machine training process (Henriikka Vartiainen, 2020). However, these children tend to overestimate the capabilities of smart devices because they need help seeing how they function internally.

Turkle notes that smart toys have changed how children perceive the liveliness of toys. Children increasingly wonder if smart toys can feel and convey emotions (Turkle et al., 2006).

Examples Connecting Technology With Children's Daily Life

Children's daily contact with technology is systematic, as they frequently observe adults using it, making it an integral part of their lives. Studies have highlighted the benefits of families learning about technology together. For example, Yu et al. demonstrated that parents initially act as spectators and then as teachers to their children when interacting with technology (Yu et al., 2020). Similarly, Michelson et al.'s research emphasised the importance of family collaboration in jointly planning technology-related activities (Michelson et al., 2021).

With the advent of smart devices at home, the entire family becomes involved in understanding interactions with AI. Children's computer games often incorporate AI, with the game's characters making decisions influenced by the child's playing style. Druga et al. showed that parents' perceptions of AI devices affect how children attribute intelligence to machines (Druga et al., 2018).

Examples of the Use of Digital Assistants

We live in an era where learning happens collaboratively and often with the help of digital assistants outside traditional educational settings (Gibson et al., 2023). Children are continuously exposed to AI technologies, yet they underestimate smart devices because they need to understand the underlying technology. Children frequently interact with digital assistants like Siri and Alexa, which perform daily tasks using voice commands. It is common for children to hear the familiar phrase "Hey Siri" when their parents want to send a message, find where they parked, or call a contact.

Methodology

We developed eight lesson plans, totaling 20 teaching hours, conducted over 15 weeks with 29 children aged 5-6 years. The children were divided into two groups: a control group and an activity group involved in the school program.

The first two lessons consisted of preliminary tests to gauge the children's pre-existing knowledge about AI. Subsequent lessons introduced programming, starting from basic principles and progressing to creating robots with sensors—the remaining lessons focused on AI, including Knowledge-Based Learning, Machine Learning, and Generative AI.

The lesson plans were aligned with our Kindergarten's educational goals and guided by Bloom's taxonomy (Bloom et al., 1956), which helped categorise our objectives for the children:

- Knowledge: Describe what AI is
- Knowledge: Recognize where AI exists
- Understanding: Understand programming
- Understanding: Interpret programming instructions
- Application: Apply AI
- Analysis: Compare if something is natural or AI
- Synthesis: Create images using AI
- Evaluation: Interpret how machines work
- Evaluation: Infer the use of AI in daily life.

At the end of the research, questionnaires were given to both groups.

Programming – Coding

The primary goal of the initial lessons was to help children understand that machines cannot function without being programmed. Programming is an unfamiliar concept for children of this age as they only experience the interface and response, not the internal operation. We began with simplified programming forms, such as BeeBots, which are simple floor-programmable robots designed like small bees. They are programmed using buttons to move forward, backwards, or turn 90 degrees right or left.

Figure 1: BeeBots on the Map

The following lessons were dedicated to Kids First Coding, an educational program where children build robots in five different models. Programs are created using a series of command cards that form the algorithm. As the robot passes over the command cards, a sensor reads them and stores the program sequentially. The robot is then placed on a track created by the children and starts executing the commands.

Figure 2: Physical Programming With the Kids First Coding Kit

At this stage, children had learned to create their first algorithm and understood the programming process. The next step involved creating robots from the Lego WeDo 2 series, which includes a central hub, a medium motor, a motion sensor, a tilt sensor, and LEGO building blocks for assembling the robot. The graphical programming software enabled children to program the robot to move, change colour, and make sounds.

Figure 3: Programming with Lego WeDo 2.0

Artificial Intelligence – Machine Learning

Lesson plans at this stage involved AI and Large Language Models (LLMs) like ChatGPT. We aimed to introduce robots into the children's daily lives as additional classmates with whom they could converse and play. One day, Alpha Mini Robot, a humanoid robot programmed to perform choreography and recognise images, appeared in the classroom. The school's IT department utilised the manufacturer's API, an external computer, Raspberry Pi 4, Google's Speech API for Greek voice recognition, and OpenAI's API to facilitate conversations with the children.

The children named the robot Luna after a vote. We programmatically informed Luna about its name, properties, and purpose, and the children were encouraged to ask it questions.

Figure 4: Luna the Alpha Mini Robot

Initially, Luna was trained to recognise common flowers and fruits familiar to the children. The children showed Luna images of daisies, roses, orchids, bananas, apples, pears, and oranges, and it recognised them.

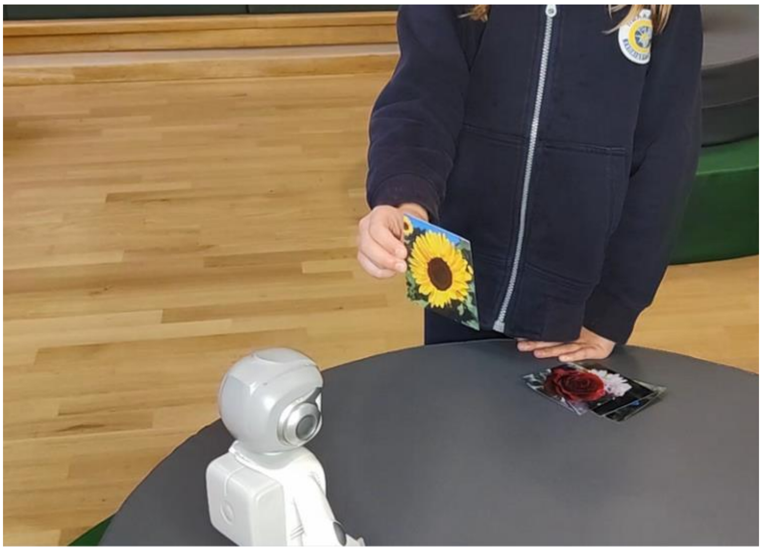

Figure 5: Luna Recognising Images

Subsequent lessons focused on training the machines themselves. Using the Teachable Machine application and cards from the game "Pigs in the Mud," the children showed each image to the camera from different angles. They wrote titles for each image, simultaneously practising keyboard writing. They then trained the machine to recognise the pictures.

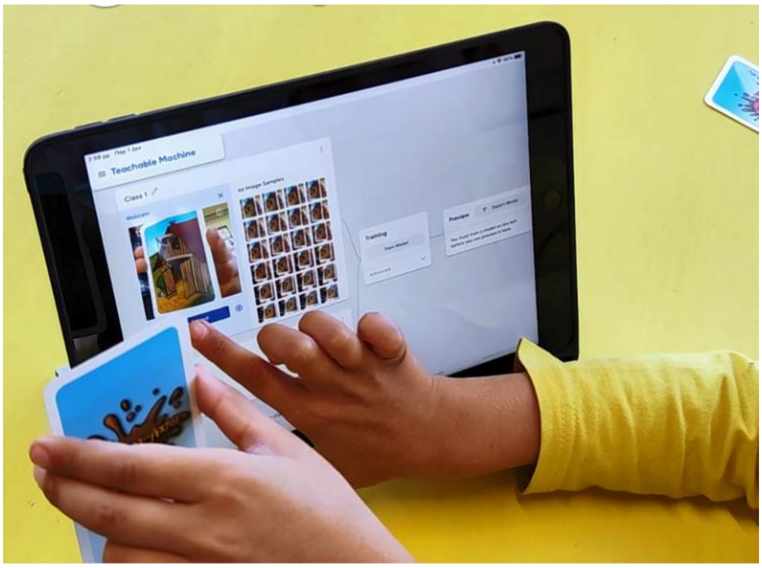

Figure 6: Training a Machine Learning Model

As Christmas approached, the children created images of Santa Claus using AI. They used prompt engineering, suggesting words like Santa Claus, sleigh, gifts, and reindeer. In the following lessons, they inserted photos and had the application describe them in detail.

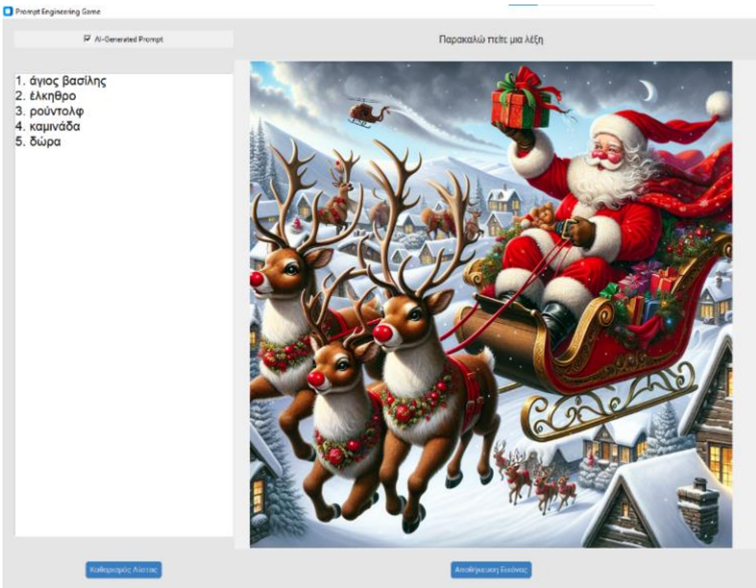

Figure 7: The Application Where Children Create Images Using Prompts

In the final lessons, the children played "rock, paper, scissors" with a new robot built at the school using a 3D printer and Raspberry Pi 5. The children trained the robot to recognise hand movements. They played the game where the robot responded with either a triumphant expression when it won or a sad expression when it lost, thus increasing empathy.


Figure 8: The New AI Robot of the School

Results

We used a questionnaire with images to assess the children's understanding of programming and AI concepts. The first part assessed technological skills acquired, and the second part included general questions about experience and interest in technology. The teacher individually administered the questionnaires to avoid influence from other children’s answers.

We statistically analysed the results in the first part by comparing the children's answers with the expected correct answers. In the second part, where there were no correct answers, we compared responses between the Trained Group (TG) and the Control Group (CG).

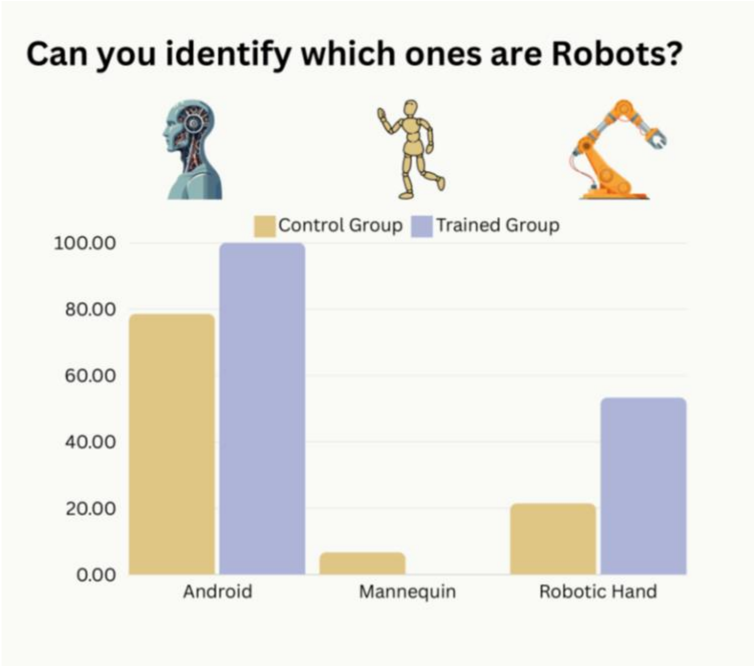

Figure 9: Results and Comparison of the Answers to the First Assessment Question – Robot Identification

This question assessed whether the children's preexisting impressions of robots usually formed through media, changed after the lessons. The trained group better understood robots, recognising that they were programmable devices.

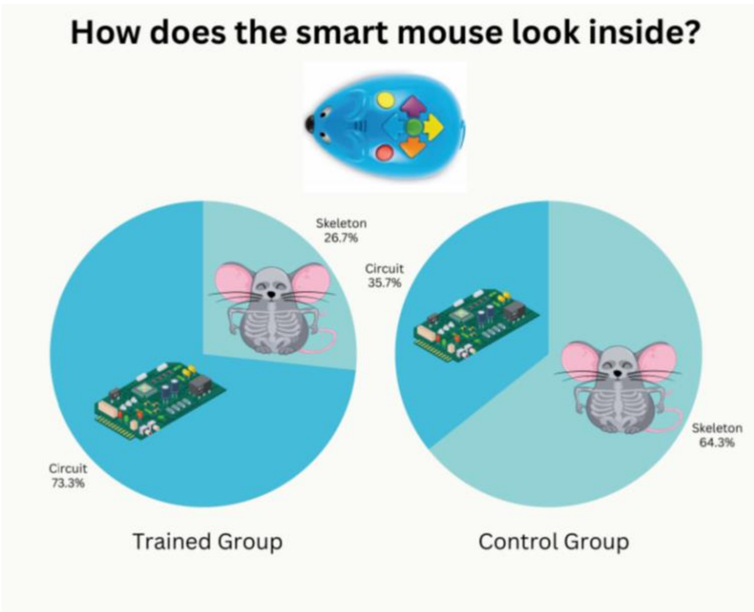

Figure 10: Results and Comparison of the Answers to the First Assessment Question – Machine Identification

This question determined whether children understood that robots do not function like living beings, even if they have animal or humanoid characteristics. The trained group showed a better understanding of robots' internal electronic components.

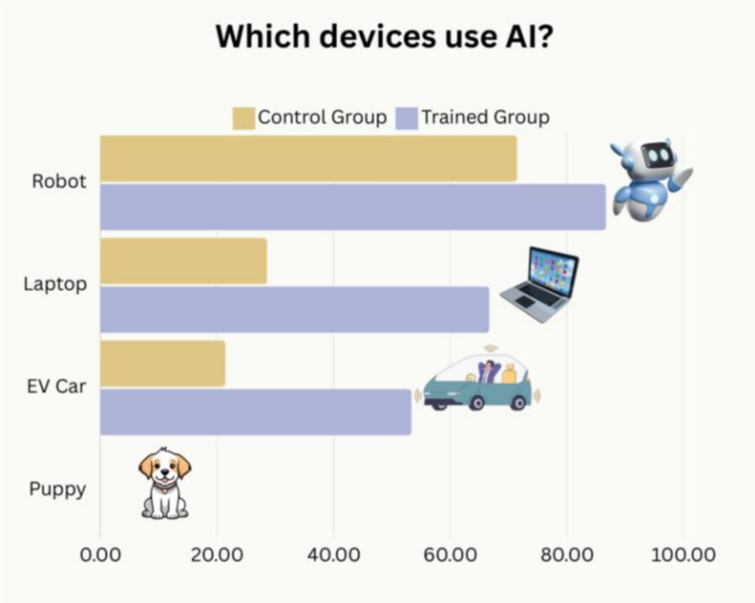

Figure 11: Results and Comparison of the Answers to the First Assessment Question – AI Identification

This figure illustrates the children's ability to identify AI after the lessons. The trained group demonstrated a significant improvement in recognising AI applications compared to the control group, indicating the effectiveness of the educational program in enhancing AI literacy.

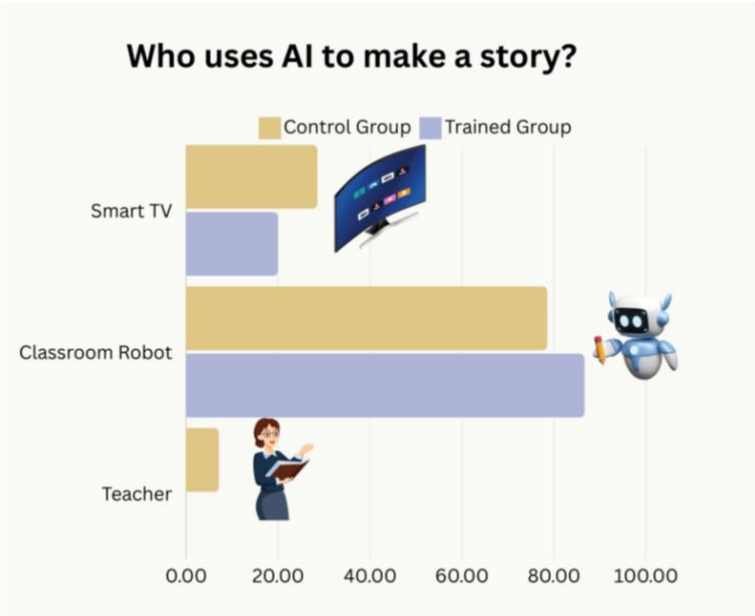

Figure 12: Results and Comparison of the Answers to the First Assessment Question – Generative AI Identification

This figure shows the children's understanding of generative AI concepts. The trained group could better identify and explain examples of generative AI, suggesting that the program successfully conveyed these advanced AI concepts to young learners.

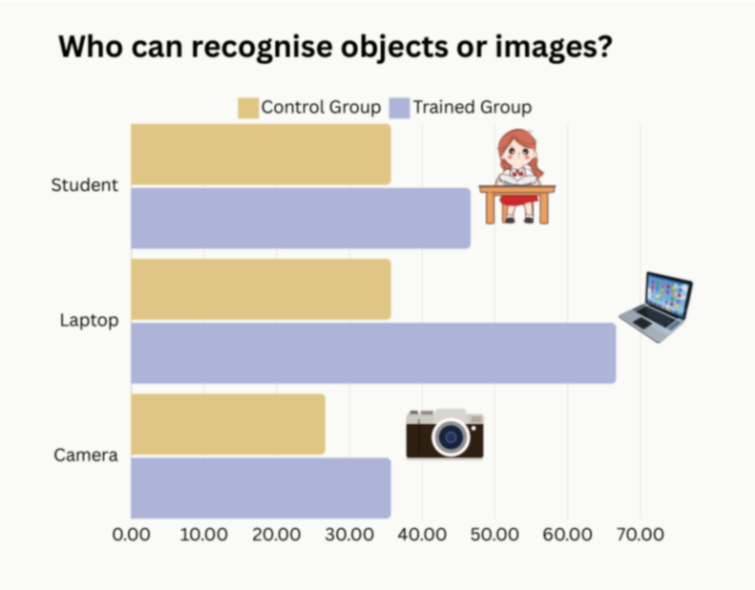

Figure 13: Results and Comparison of the Answers to the First Assessment Question – Machine Learning Identification

This figure compares the children's comprehension of machine learning. The trained group showed a higher ability to recognise and describe machine learning processes, demonstrating the program's impact on their understanding of how AI learns from data.

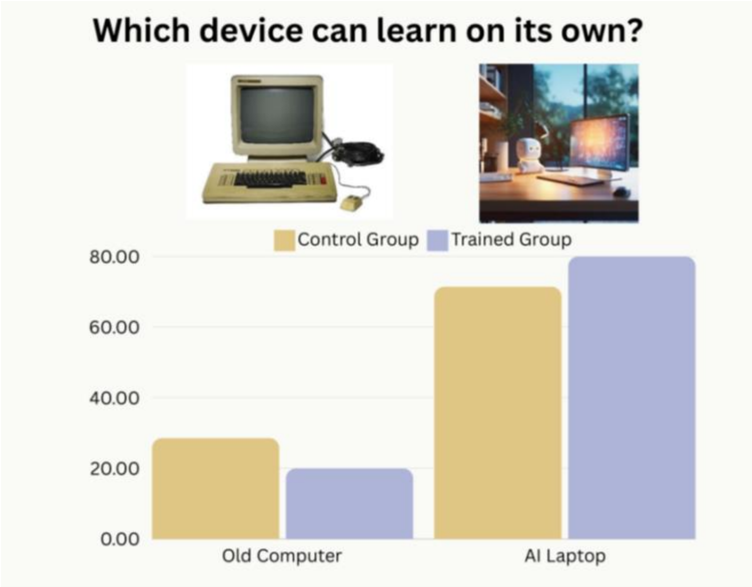

Figure 14: Results and Comparison of the Answers to the First Assessment Question – Self-Training AI Identification

This figure examines the children's grasp of self-training AI systems. The responses indicate that the trained group better understood AI, which can improve over time, highlighting the depth of knowledge gained through the program.

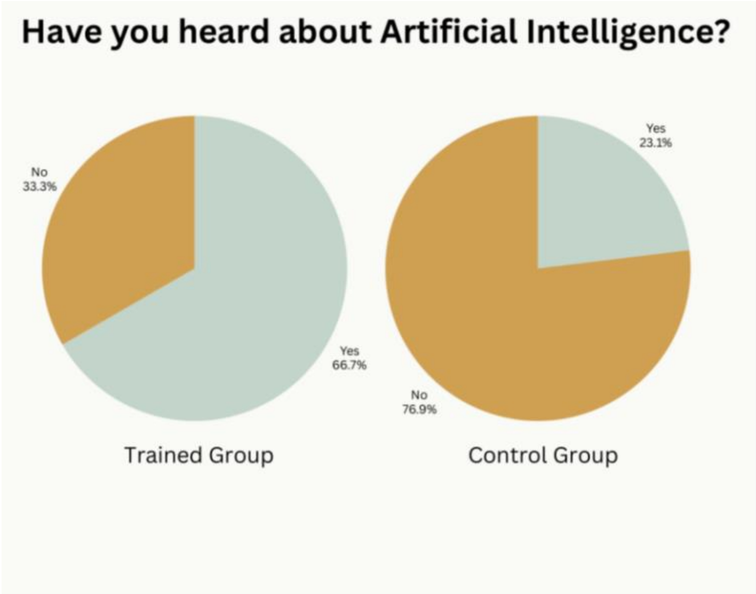

Figure 15: Results and Comparison of the Answers to the First Assessment Question – Self-Assessment

This figure presents the children's self-assessment of their understanding and interest in AI and programming. The trained group reported higher confidence and interest levels, reflecting the program's success in engaging and educating young minds about AI.

Discussion

The results suggest that children's exposure to AI tools enhances their understanding of programming and technology-related concepts. By creating material through applications, they better understood AI and its capabilities. Although children interact with technology daily at home, they previously needed to understand what AI is and recognise it in applications.

The pilot AI applications introduced this year in kindergarten will form the basis for designing a comprehensive program for children aged 4-6. The program aims to continue the research and disseminate information to the school's educators and other interested parties in education.

Conclusions

In this work, we presented lesson plans in an early but coherent and complete form. The goal was to investigate whether children who attended the program acquired additional digital cognitive skills, learned to recognise and use AI applications, and understood the logic behind "smart" machines.

The research showed that despite their lack of prior knowledge and technological skills, children significantly understood the current use of robots and AI. They learned to program and recognise AI in daily functions.

Having two groups of children in the same school, with only one group exposed to the educational program, allowed us to draw valuable conclusions about the program's impact on children's perception of AI.

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