Chapter 11

The Importance of Artificial Intelligence in Preschool Science Education in the Context of Long-lasting Learning

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Abstract

This chapter examines the role of artificial intelligence (AI) technologies in enhancing long-lasting (permanent) learning in preschool science education. The use of AI in developing scientific thinking skills during early childhood offers numerous advantages, increasing children's engagement with the subject matter and encouraging active participation in learning processes. AI-based tools can be adapted to meet individual learning needs, allowing for the personalization of educational experiences. By providing an interactive and engaging environment, AI applications offer experimental learning opportunities that contribute to long-lasting retention of scientific concepts. The chapter discusses how AI supports children's cognitive development, problem-solving skills, curiosity, and self-confidence. Particularly in developing problem-solving and analytical thinking, AI technologies equip children with tools to tackle complex problems and think critically. Additionally, the chapter emphasizes the role of teachers in AI-supported learning environments and the pedagogical knowledge required for the effective use of these technologies. Moreover, ethical and safety considerations surrounding AI technologies in early childhood education are explored. Ensuring children's data privacy and digital safety is essential for the broader acceptance and application of AI in educational contexts. In this regard, the chapter provides recommendations for the safe and effective implementation of AI in education and presents projections on the potential future impact of this technology on educational practices.

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1. Introduction

In recent years, the role of artificial intelligence (AI) technologies in education has been increasingly emphasized, and the use of these technologies in early childhood education has also drawn significant attention. Early science education plays a critical role in providing children with fundamental knowledge and skills related to scientific concepts. Science education designed to support long-lasting learning fosters children's innate curiosity and directs them towards scientific thinking (Şahin, 2020).

The rapid development of AI technologies has led to the adoption of innovative approaches in the field of education, resulting in transformative changes in learning processes. Integrating AI into early childhood education presents new opportunities for children's cognitive, social, and emotional development (Kaya and Çakır, 2021).

Teaching fundamental knowledge and skills related to scientific concepts during preschool education is of great importance for children's development of scientific thinking skills in the long term (Demir and Yılmaz, 2019). In this regard, AI emerges as a crucial tool in providing an interactive and enduring learning experience in children's educational processes.

Long-lasting learning refers to a process in which students retain information for extended periods and can apply this knowledge in various contexts. This type of learning requires in-depth understanding rather than surface memorization (Caine and Caine, 2011). AI-supported learning environments help children understand scientific concepts through experience, making the learned information more long-lasting.

Studies indicate that AI contributes to children's deep comprehension of scientific topics by offering interactive and personalized learning experiences (Özkan and Çakır, 2020). These learning processes allow children to apply what they have learned in real-life situations and different contexts.

The personalization opportunities offered by AI contribute to equity in education by adapting the learning process to each child's individual needs (Yılmaz, 2017). For instance, AI-based applications that can be customized to match children's learning speeds and interests encourage deeper learning in disciplines like science education (Akın and Demir, 2022). This approach allows each child to progress at their own pace, exploring scientific concepts independently.

Such personalized learning experiences help children ascribe more meaning to knowledge, thus supporting long-lasting learning (Gökçe and Karaman, 2020).

AI applications that encourage active participation in learning processes during the preschool period increase children's motivation to learn, fostering long-term interest and commitment to science. AI-supported games and simulations enhance children's interest in science and encourage them to explore and inquire. This process transcends mere knowledge transmission, enabling children to develop scientific inquiry skills (Yıldırım, 2018).

Additionally, AI contributes to children's social and emotional development in the context of science education; children learn through teamwork and interaction with peers (Korkmaz, 2019).

In summary, this chapter focuses on the potential impact of AI on long-lasting learning in preschool science education, highlighting the importance of this technology in developing children's scientific thinking skills. T

This section aims to detail the contributions of AI-supported educational applications to children's science education, offering an in-depth analysis of their pedagogical and technological effects on the learning process.

2. The Relationship Between Artificial Intelligence and Long-lasting learning

Artificial intelligence (AI) creates a profound transformation in knowledge-based learning processes, assisting students in retaining learned information over the long term. Long-lasting learning is a process that enables students to remember acquired information not just temporarily but for an extended period, applying it in daily life (Atkinson and Shiffrin, 2016).

AI offers personalized and interactive learning environments that facilitate this level of knowledge retention. Learning processes supported by AI-based applications allow children to understand, apply, and retain learned information more long-lastingly (Korkmaz and Çetin, 2020).

The effect of AI on long-lasting learning is based on its capacity to tailor learning experiences to students' individual needs. AI provides personalized guidance and educational content at a pace suited to each learner's progress. Individualized education is crucial in promoting long-lasting learning, especially during early childhood when children exhibit varying learning speeds (Shute and Zapata-Rivera, 2012).

Thus, children can progress at their own pace within a learning process adapted to their needs, allowing for a deeper comprehension of the knowledge they acquire. In the context of long-lasting learning, AI does more than transmit information; it helps children make sense of and apply

knowledge. For example, virtual tutors or interactive digital games encourage children to explore scientific concepts while actively engaging in the learning process (Çiftçi and Erdoğan, 2018). When children have the opportunity to experience scientific concepts through games or simulations, they construct these concepts mentally more robustly, retaining the knowledge for longer. In this way, AI stands out as one of the tools promoting long-lasting learning in preschool education.

AI technologies are also effective in supporting children's cognitive and affective learning goals, enhancing skills like scientific thinking and problem-solving. Understanding scientific concepts in preschool supports children's interest in science in later years, guiding them toward scientific inquiry (Aksoy and Şimşek, 2019). AI in this process becomes a supportive technology in preschool science education that fosters long-lasting learning through experiential and observational learning.

AI's impact on long-lasting learning in preschool science education is significant. AI-supported interactive learning environments help children relate abstract scientific concepts to tangible experiences, aiding comprehension and retention. In this context, the personalization, interactivity, and feedback mechanisms AI provides enable children to engage more actively in learning processes, allowing them to retain knowledge of scientific topics for extended periods (Güneş and Çakmak, 2020).

2.1. The Contribution of Artificial Intelligence to Long-lasting and Meaningful Learning

Artificial intelligence (AI) has become a powerful tool in supporting long-lasting learning in education. Long-lasting learning enables students to retain knowledge for extended periods and use it effectively across various contexts (Eysenck, 2015).

AI technologies make learning processes more meaningful by helping children internalize and retain information. In other words, as meaningful learning increases, knowledge becomes more concentrated and long-lasting. Through AI-supported applications, children do not merely acquire information superficially but have the opportunity to actively experience and apply it (Johnson, 2018). This engagement fosters a deep involvement in learning processes, thereby contributing to the meaningful and long-term retention of knowledge.

AI personalizes the learning process by considering individual learning differences, tailoring each student's learning journey. Personalized learning experiences allow children to learn at their own pace and according to

their interests. For example, some children are more inclined toward visual learning, while others prefer learning by doing. AI-supported tools cater to these individual differences, providing suitable content for each learner (Chauhan, 2021). Consequently, learning experiences become more effective and enduring, as research has shown that personalized learning has a stronger impact on long-lasting learning.

AI's contribution to long-lasting learning is also evident in its ability to offer interactive learning environments where children actively engage with the content. Interactive learning enables children to understand and apply knowledge through experience. For example, AI-supported simulations or games in science education allow children to experience scientific concepts visually and auditorily. These applications enhance retention by reinforcing learned information through multisensory experiences (Clark and Mayer, 2016). Interactive learning prevents children from passively receiving information, instead encouraging them to investigate and make sense of knowledge. Another significant contribution of AI to long-lasting learning lies in its capacity to provide continuous feedback. AI-based systems monitor children's learning processes, identifying areas needing improvement, and offer immediate feedback (Özkan and Çakır, 2020). This feedback makes learning more effective and aids in the long-term retention of knowledge (Chen, Rau, and Chen, 2019). Additionally, such feedback allows children to manage their learning processes by recognizing and learning from mistakes. Students can build a solid knowledge base by correcting errors and learning from them.

AI technologies' personalization, interactivity, and feedback mechanisms create an ideal environment for long-lasting learning. These technologies facilitate meaningful and profound learning processes that help children retain knowledge over extended periods. In preschool science education, AI emerges as a valuable tool, enabling children to learn scientific concepts more effectively and retain this knowledge in the long term (Mitchell, 2020).

3. The Role of Artificial Intelligence in Preschool Science Education

Artificial intelligence (AI) plays an essential role in preschool science education by enabling children to understand scientific concepts and participate more actively in learning processes (Zhu, Han, and Gao, 2021). Science education aims to help children comprehend the world around them and develop scientific thinking skills, and the knowledge acquired at this age can impact their future scientific success (Chen et al., 2019). AI facilitates

the involvement of young children in science education, allowing them to have meaningful and enduring learning experiences (Holmes, 2018).

One of AI's most important functions in preschool science education is to provide children with opportunities to learn abstract scientific concepts through concrete experiences. AI-based technologies such as AR (Augmented Reality) and VR (Virtual Reality) allow children to observe abstract topics like the solar system, water cycle, or plant life cycle. These experiences make it easier for children to understand scientific concepts and retain this knowledge for extended periods (Billinghurst, 2016). For instance, an AR application can enable children to observe the growth and development of a plant in 3D, thereby deepening their understanding of environmental processes.

AI-supported educational tools also increase children's interest in science topics, encouraging greater engagement in the learning process. For example, AI-based simulations and games allow children to explore scientific subjects in an enjoyable and interactive way. These engaging experiences maintain children's interest in science and motivate them to ask questions and explore further (Luckin et al., 2016). Studies show that children learn more effectively and retain knowledge better in interactive learning environments (Chen, 2018).

Additionally, AI provides a personalized learning experience that considers individual differences in children's learning processes. As each child has a unique learning pace and set of interests, AI-supported tools can adapt to meet each child's needs (Holstein, McLaren, and Aleven, 2019). For example, while some children learn better through visual content, others prefer learning by doing. AI monitors children's learning processes and provides suitable content for each child, allowing them to learn at their own pace.

AI, therefore, emerges as an important technology supporting children's comprehension of scientific concepts and development of scientific thinking skills in preschool science education. AI-supported tools and applications enable children to participate actively in science education, making the learning process more meaningful and long-lasting. In this context, AI technologies can be seen as innovative educational tools that help children understand scientific concepts better and retain this knowledge in the long term (Mitchell, 2020).

3.1. AI-Based Interactive Tools in Preschool Science Education

Artificial intelligence (AI)-based interactive tools are effectively utilized in preschool science education to enhance children's scientific skills and ensure active participation in learning processes. These tools provide visual, auditory, and experiential learning experiences that support children's science knowledge skills (Papert, 2020).

Interactive AI-based tools enable children to understand the world around them from a scientific perspective, allowing them to explore fundamental scientific concepts in-depth. By learning science knowledge skills in a hands-on way through these tools, children make knowledge more long-lasting (Chen et al., 2019).

One of the most significant features of AI-based interactive tools is their ability to offer applications aimed at developing children's scientific process skills. For instance, through educational robots or simulations, children can experience scientific processes such as observation, data collection, analysis, and drawing conclusions. In these processes, children recognize that knowledge is not only theoretical but also an applied process. Developing scientific process skills contributes to children's positive attitude toward science and advances their scientific thinking skills. In preschool science education, AI-based tools provide children with opportunities to make mistakes and learn from them. Interactive tools allow children to develop solutions through trial and error while learning scientific concepts. By using AI-supported simulations, children can try their own solutions, make mistakes, and receive instant feedback to correct these errors (Holmes, Bialik, and Fadel, 2020). This process enables children to understand scientific processes more deeply and boosts their self-confidence.

AI-based tools encourage children to ask questions about science and foster their curiosity. When children interact with AI-supported games or simulations, they begin to ask questions about events they observe in their environment. For example, a child observing seasonal changes through an AI simulation may develop curiosity about weather phenomena (Rosenberg and Jack, 2017). Such interactions enhance children's curiosity toward science and foster their scientific inquiry skills.

AI-based interactive tools that play a crucial role in building the foundation of scientific thinking skills in preschool science education encourage children to actively participate in scientific thinking processes while developing their science knowledge skills. These tools make the learning process more meaningful by allowing children to explore scientific concepts practically (Zhu and Leung, 2020).

3.2. AI-Supported Applications in the Context of Cognitive and Affective Development

Artificial intelligence (AI) provides significant support for children's cognitive and affective development in preschool education, contributing positively to their learning processes. Cognitive development encompasses skills such as thinking, problem-solving, reasoning, and comprehension, while affective development involves emotional processes like self-confidence, curiosity, interest, and motivation (Piaget, 2001). AI-supported applications offer interactive and adaptive learning environments designed to enhance children's cognitive and affective skills. Particularly in early childhood, AI-based educational tools are effective in fostering scientific thinking skills and increasing interest in science (Bower and Sturman, 2015).

In terms of cognitive development, AI enables children to develop problem-solving and analytical thinking skills. For example, educational robots and interactive games actively engage children in problem-solving processes. In these AI-supported applications, children encounter various challenges, search for solutions, and generate hypotheses. Such applications support children's logical thinking abilities and help them develop solutions when faced with complex problems (Resnick, 2017). Furthermore, children are encouraged to apply what they have learned in different situations, promoting long-term knowledge retention. For affective development, AI-supported applications boost children's self-confidence and support their motivation to learn. In interactive learning environments, children can direct their own learning processes and receive instant feedback in cases of failure, improving their learning experiences. Instant feedback provided by AI allows children to recognize and correct their mistakes, increasing their self-confidence (Papadakis, 2020). Additionally, AI-supported games and simulations maintain children's interest in science and encourage them to explore, which fosters their active engagement in learning processes.

AI also has the potential to enhance children's social-emotional skills. AI-based applications offer learning experiences that promote teamwork and collaboration. For example, AI-supported educational games used in groups allow children to improve communication skills and interact with each other. These interactions help children develop social skills such as empathy, patience, and cooperation. Supporting social interactions enriches children's individual and group learning experiences. AI-supported educational tools contribute to both children's cognitive and affective development, increasing their interest and achievement in science. Interactive, adaptable, and instant feedback-providing AI learning environments support children's cognitive

processes and positively influence their affective development (Zhu et al., 2021). Consequently, AI-supported applications enable children to acquire fundamental skills related to science and retain this knowledge over the long term.

4. Applications of Artificial Intelligence in Preschool Science Education

Artificial intelligence (AI) offers a range of applications that enable children to explore and understand scientific concepts in preschool science education. While developing children's science knowledge skills, AI-based applications also support their scientific thinking and problem-solving abilities. AI tools in science education make it easier for children to access scientific knowledge and actively engage in learning experiences (Tzafestas, 2020). In preschool, AI technologies help connect abstract scientific concepts with concrete experiences, increasing children's interest in science.

One of the most common uses of AI in preschool science education is educational robots. These robots enable children to explore fundamental concepts in science and enhance their problem-solving skills. Educational robots present task-based learning opportunities, encouraging children to participate in scientific experiments (Alimisis, 2013). Through these robots, children can conduct experiments, solve problems, and develop hypotheses. Such interactions support children's understanding of scientific processes and contribute to the retention of knowledge.

AI also provides instant feedback during children's learning experiences in science, allowing them to identify their shortcomings and correct errors. For instance, an AI-supported science education application can analyze children's mistakes and offer corrective feedback. This type of feedback enhances the learning process and reinforces the retention of knowledge (Sarikaya and Aydin, 2018). Learning experiences supported by instant feedback contribute to long-lasting knowledge retention.

In summary, AI offers a wide range of applications in preschool science education that help children understand scientific concepts through various tools. AI-supported tools like educational robots, AR/VR applications, and feedback mechanisms increase children's interest in science and make knowledge retention more long-lasting. In this context, integrating AI technologies into preschool science education enables children to develop scientific thinking skills and gain a deeper understanding of scientific topics (Zhang et al., 2019).

4.1. Integration of Artificial Intelligence with Virtual and Augmented Reality in Science Education

One significant application of artificial intelligence (AI) in preschool science education is its integration with augmented reality (AR) and virtual reality (VR). AR and VR allow children to explore abstract concepts in science education through visual and interactive experiences, making learning more meaningful and long-lasting (Chang, Chang, and Shih, 2020). Thus, AI enhances the learning process through active participation.

AI-supported technologies such as VR and AR create engaging learning experiences in science, enabling children to understand scientific concepts more effectively. Through these technologies, children can observe and interact with abstract scientific concepts in a three-dimensional environment.

With VR and AR, children can experience scientific theories and processes in a concrete way, developing a deeper understanding of scientific knowledge (Billinghurst and Duenser, 2012). The integration of AR and VR with AI encourages children to actively participate in the learning process, making scientific concepts more enduring.

The integration of VR and AR in science education allows children to explore the world around them from a scientific perspective. For example, with VR, children can observe planetary movements in space or examine the structure of the human body. These experiences help children understand abstract scientific concepts in a more concrete way (Radu, 2014). Additionally, with AR, children can directly associate scientific information with objects in their environment and relate them to scientific processes. For example, through AR, children can observe information about photosynthesis on a leaf, gaining a better understanding of this process.

AI-supported VR and AR applications enable children to participate actively in the learning process and learn at their own pace. Adaptive VR and AR tools powered by AI provide tailored educational content based on children's individual learning speeds and preferences (Cheng and Tsai, 2013). This personalized learning experience allows children to gain a deeper understanding of scientific knowledge. Moreover, interactive elements in VR and AR applications increase children's interest in science, motivating them to explore and learn.

VR and AR technologies are also effective in helping children develop scientific observation, analysis, and hypothesis-building skills. Through VR and AR, children can observe and analyze various scientific processes, strengthening their scientific thinking abilities. For instance, a VR application

that demonstrates the water cycle allows children to observe the processes of evaporation, condensation, and precipitation, enabling them to make inferences about this cycle. Such experiences contribute to the long-lasting retention of scientific knowledge.

The integration of AI-supported VR and AR technologies in science education provides children with opportunities to understand scientific concepts and develop scientific thinking skills. The visual and interactive experiences offered by VR and AR keep children engaged in science while nurturing their curiosity about scientific phenomena. In this context, AI-integrated VR and AR applications emerge as powerful tools that enrich and enhance the learning process in preschool science education (Chen and Chan, 2019).

4.2. The Role of Games and Simulations in Science Education

AI-supported games and simulations provide interactive and enjoyable learning experiences in science education, allowing children to better understand scientific concepts. Games and simulations enable children to make abstract science topics more tangible and encourage active participation in the learning process. Through games, children can experience scientific concepts in a fun environment, making the knowledge they gain more long-lasting (Gee, 2008). AI-based games and simulations increase children's motivation to explore and learn, making science education more engaging.

AI-supported games offer children the opportunity to develop scientific thinking and problem-solving skills. For example, in an ecosystem simulation, children can observe the effects of environmental factors on plants and animals, helping them understand cause-and-effect relationships. In these types of games, children have the opportunity to explore scientific concepts through various scenarios, supporting their comprehension and long-term retention of scientific knowledge.

Games and simulations also encourage children to develop curiosity and scientific inquiry skills by supporting their science knowledge skills. AI-supported games provide children with the opportunity to make mistakes and learn from them. While developing a hypothesis or experimenting in a game setting, children can make mistakes and receive instant feedback, helping them improve their learning processes (Connolly et al., 2012). This process fosters active participation in learning and contributes to the development of scientific thinking skills.

AI-supported games and simulations help children enhance their scientific observation and analysis skills. Through AI-based simulations, children can

make direct observations and analyze scientific events to make inferences. For instance, a game simulating the water cycle allows children to observe the stages of this cycle and understand how each phase occurs. Such games enable children to develop a deeper understanding of science topics.

In conclusion, AI-supported games and simulations are innovative and effective tools for science education. These tools facilitate children's understanding of scientific concepts and support the development of scientific thinking and problem-solving skills. AI-supported games encourage children's interest in science and their active participation in learning processes (Wouters et al., 2013). Therefore, the use of AI-supported games and simulations in science education contributes to building a solid foundation of scientific knowledge in children.

5. Artificial Intelligence-Supported Learning Approaches

Artificial intelligence (AI) enables new teaching approaches in education, making learning processes more effective for both teachers and students. AI-based instructional approaches provide individualized content to students while offering data to teachers for monitoring student performance and improving teaching strategies (Luckin et al., 2016). In preschool science education, AI-supported teaching helps children gain a deeper understanding of science topics and actively engage in the learning process. AI-supported instructional approaches make learning experiences more meaningful, supporting long-lasting learning.

One key advantage of AI-supported instructional approaches is the ability to improve teaching processes by providing teachers with data on children's individual learning progress. Through AI-based tools, teachers can analyze students' achievement levels, interests, and learning speeds to adapt their teaching strategies. Such data-driven instruction makes learning experiences more effective, encouraging children to engage more in the learning process (Chen and Chen, 2018). Teachers can identify each child's strengths and weaknesses and provide support tailored to their needs.

AI-supported instruction also offers teachers the opportunity to personalize the learning environment. Each child has unique learning styles, speeds, and needs, making it essential to adapt teaching environments to individual differences. AI-based systems analyze children's learning processes and tailor the learning experience to meet their needs, supporting individualized learning (Baker and Smith, 2019). This approach allows each child to progress at their own pace in science education, enhancing the durability of knowledge.

AI-supported instructional approaches increase children's interest and motivation toward science, fostering active engagement in learning. For instance, children can experience science topics through AI-supported simulations or educational games. Such teaching methods nurture children's curiosity and encourage them to explore scientific concepts. Thus, AI-supported instructional approaches go beyond mere information transfer, aiming to develop children's scientific thinking and problem-solving skills (Rosenberg and Jack, 2017).

AI-supported instructional approaches offer teachers numerous opportunities to support children's individual learning processes and personalize instruction. These approaches allow children to develop a lasting understanding of science while also enabling teachers to enhance instructional processes and tailor them to student needs. Integrating AI technologies into instructional approaches contributes to a more efficient and long-lasting science education.

5.1. AI-Supported Interactive Learning

AI-supported interactive learning enables children to actively participate in the learning process, making knowledge more long-lasting. AI-based interactive learning environments make it easier for children to engage with abstract concepts in science education, providing meaning to these concepts (Clark and Mayer, 2016). Interactive learning environments prevent superficial learning by allowing children to reinforce learned information through various experiences. Especially in early childhood, active involvement in exploration, experimentation, and learning processes helps retain information longer in memory.

AI-supported interactive learning tools help students associate abstract concepts with tangible experiences. Technologies such as augmented reality (AR) and virtual reality (VR) enable children to better understand complex concepts in science education by visualizing them. These technologies allow children to establish a direct connection with the world around them, making learning more meaningful. When children explore scientific concepts through interactive simulations and games, these experiences ensure long-lasting knowledge retention and contribute to the development of scientific thinking skills.

Furthermore, AI-supported interactive learning environments allow children to actively discover information. In these environments, children learn science by conducting experiments or making observations. For instance, an AI application simulating the growth process of a plant helps

children understand the life cycle of plants. Experiential learning like this not only helps children acquire information but also enables them to understand it deeply and retain it for a long time. Thus, AI-supported interactive learning supports long-lasting learning by promoting children's active involvement in the learning process.

AI-supported interactive learning not only aids cognitive development but also contributes to affective development. Children take responsibility for their learning processes in interactive learning environments, which enhances their self-confidence. Additionally, active participation in the learning process increases children's motivation, sustaining their interest in science education. This motivation drives children to ask scientific questions and fuels their desire to explore, thereby fostering their scientific thinking and inquiry skills (Chen et al., 2019).

5.1. AI-Supported Discovery and Experiential Learning

AI-supported learning environments allow children to explore science topics and learn through hands-on experiences. Discovery and experiential learning involve children actively experiencing and understanding information through their own investigations rather than memorization. This approach helps children make sense of their surroundings and fosters the development of scientific thinking skills. AI provides an interactive learning experience that guides children in this process, adapts to their learning pace, and offers instant feedback (Kim, Park, and Lee, 2020).

In discovery and experiential learning, children can experience scientific concepts visually through AI-supported simulations and virtual reality (VR) applications. Complex scientific concepts, such as the water cycle, planetary movements, or life cycles, can be made accessible to children through AI-based simulations, allowing them to observe and interact (Billinghurst and Duenser, 2012). These experiences enable children to understand abstract scientific concepts better and support long-lasting knowledge retention.

AI encourages children to learn independently in the discovery-based learning process, offering opportunities to ask scientific questions, develop hypotheses, and create solutions. In an AI-supported learning environment, children tackle scientific problems by creating their solutions, enhancing their problem-solving abilities (Resnick, 2017). This process not only improves children's scientific thinking skills but also boosts their confidence, as they can validate the accuracy of their discoveries.

Interactive AI tools allow children to make mistakes in experiential learning processes and learn from them. During their learning journeys,

children receive instant feedback from AI systems as they make mistakes, allowing them to reassess their solutions based on this feedback. This process enables children to learn through experience and make knowledge more long-lasting by learning from errors (Johnson, 2018). Thus, AI-supported learning environments help children direct their learning processes.

In conclusion, AI-supported discovery and experiential learning enable children to understand scientific concepts better and experience a learning process that supports long-lasting knowledge retention. Interactive learning environments that actively involve children in the learning process enhance their interest in science and promote the development of scientific skills (Dede, 2009). AI serves as a guiding tool in children's exploration of science, contributing to their long-term knowledge and skills.

5.3. AI-Supported Personalized Learning

AI-based personalized learning approaches ensure that each child has an educational experience tailored to their learning pace, interests, and needs. In preschool science education, aligning learning processes with children's individual learning differences makes learning more effective and meaningful (Chen et al., 2019). AI analyzes children's learning processes, assesses each student's information retention rate and level of comprehension, and offers an adaptive learning experience accordingly. This personalized learning experience enhances children's interest and motivation toward science.

In AI-supported personalized learning environments, educational materials are adapted to meet the needs of each child. For example, a child inclined toward visual learning might be provided with more visual materials, while a child who prefers hands-on learning could be given interactive simulations (Shute and Zapata-Rivera, 2012). This approach allows each child to develop science knowledge skills using materials that suit their learning style. By offering content aligned with children's needs, AI supports long-lasting knowledge retention.

AI individualizes learning by providing instant feedback during the learning process. As children study a topic, they receive immediate feedback on their mistakes or deficiencies, allowing them to improve based on this feedback. In science, learning through mistakes fosters children's ability to think critically about knowledge, cultivating a deep understanding of scientific processes (Van Lehn, 2011). Therefore, the instant feedback mechanisms provided by AI support individualized learning.

AI-supported personalized learning approaches also contribute to the development of children's self-regulation skills. Self-regulation refers to

children's ability to manage their own learning processes, set goals, and develop strategies to achieve them. AI-supported learning environments allow children to monitor their own progress, raising their awareness of their learning process (Holmes, 2018).

Developing self-regulation skills helps children manage their learning processes more effectively, particularly in science education.

In conclusion, AI-supported personalized learning approaches enrich children's learning experiences, making science knowledge more long-lasting. AI supports active participation in learning by offering content and feedback tailored to each child's individual learning needs (Chen, 2018). These personalized learning approaches increase children's interest in science, contributing to the development of scientific skills.

5.4. Pedagogical Approaches in AI-Supported Learning

Pedagogical approaches in AI-supported learning processes aim to enrich children's learning experiences and support long-lasting learning. These approaches provide adaptive and personalized learning environments that support children's cognitive and affective development (Holmes, 2018). AI-supported pedagogical approaches increase children's interest in science, promoting the development of scientific thinking skills by presenting a structure tailored to each child's individual needs. Grounded in pedagogical principles, these approaches encourage children to take an active role in science education, making the learning process more meaningful (Baker and Alexander, 2018).

From a pedagogical perspective, AI integration into learning processes offers a structure adaptable to each child's learning speed and style. Every child has a unique learning style and pace, and instructional strategies that consider these individual differences are more effective.

AI-based systems analyze children's learning processes, personalizing the learning experience and supporting individualized learning (Uskov, Howlett, and Jain, 2018). This way, each child can progress at their own pace in science topics, enhancing knowledge retention.

AI-supported pedagogical approaches encourage children to be interactive and participatory in the learning process. Through AI-based games, simulations, and educational software, children can explore and understand scientific topics. Interactive learning environments do more than expose children to information; they help children interpret and understand it (Roll and Wylie, 2016). Thus, AI-supported pedagogical approaches

contribute to long-lasting retention of scientific knowledge by promoting children's active participation in the learning process.

Teachers play a crucial role in these processes. In AI-supported learning environments, teachers guide children's learning processes, helping them give meaning to knowledge. In a pedagogically strong AI-supported education, teachers direct the learning process according to the children's needs and provide the necessary support (Holstein, McLaren, and Aleven, 2019). It is essential for teachers to have adequate knowledge and training on AI technologies to use these technologies effectively for pedagogical purposes.

In conclusion, pedagogical approaches in AI-supported learning processes provide a structure that supports long-lasting learning in science education. These approaches adapt to children's individual needs, promote active engagement, and benefit from teacher guidance, contributing to the long-lasting understanding of scientific concepts (Luckin et al., 2016). In this context, AI-supported pedagogical approaches hold great potential for enhancing preschool science education and making learning processes more effective.

6. Conclusion and Discussion

AI emerges as an effective tool that enables children to understand scientific concepts more deeply and develop scientific thinking and problem-solving skills. AI-based applications used in preschool promote children's active participation in learning processes, making these processes more meaningful (Holmes et al., 2020). Additionally, personalized and interactive AI-supported learning environments increase children's interest in science, supporting long-lasting knowledge retention.

AI technologies can adapt to children's individual learning needs, enriching the learning process by providing content that aligns with each student's pace, interests, and requirements. As children progress at their own pace, they can enjoy learning while gaining a better understanding of scientific concepts. Research has shown that AI-supported personalized learning environments enhance children's engagement in learning processes and make learning more long-lasting (Chen, 2018). In this context, the adaptability and personalization offered by AI make learning processes more efficient.

However, there are challenges associated with using AI in preschool education. Developing and implementing AI-based tools requires technical knowledge, which necessitates enhancing teachers' competencies. Additionally, ethical concerns, such as data privacy and children's safety,

should be addressed when implementing AI. Effective policies and procedures are needed to ensure children's digital security (Luckin et al., 2016). Thus, supporting teacher training and strengthening security measures are crucial for the effective use of AI in education.

Another aspect to discuss is the impact of AI-supported learning tools on children's social interaction skills. While AI-based education supports individualized learning experiences, it should also provide environments that enhance children's social skills. Research indicates that AI can support social skill development; however, more programs promoting collaboration, teamwork, and empathy among children are needed (Holstein et al., 2019). Socially interactive learning environments support both cognitive and affective development, offering a more comprehensive approach to science education.

In conclusion, AI-supported educational technologies can be seen as innovative tools that help preschool children acquire scientific skills, increase their interest in science, and support long-lasting learning experiences. Ethical, safety, and teacher training aspects must be considered for the effective use of AI in education. In the future, with the broader use of AI in education, preschool science education can better support children in understanding scientific concepts and retaining this knowledge in the long term (Zhu and Leung, 2020).

7. Recommendations

To effectively utilize artificial intelligence (AI)-supported educational technologies in preschool science education, certain strategic recommendations must be developed. Firstly, it is essential to create a comprehensive teacher training program on the use of AI in education. Teachers need to develop their knowledge and skills regarding AI-based tools to use them effectively. Therefore, teacher education programs should be enriched with content on the pedagogical use of AI (Holstein et al., 2019). These programs will enable teachers to implement AI in classrooms more effectively and consciously.

Secondly, strong security measures must be taken to protect children's data privacy and security in AI-supported educational applications. Particularly in early childhood, attention should be given to the collection and use of children's data. Educational institutions and AI developers are advised to clearly establish data collection policies and apply security protocols to ensure children's digital safety (Luckin et al., 2016). Additionally, informing parents about this matter will help ensure that children are safe when interacting with AI-supported tools.

Thirdly, it is recommended to increase collaborative applications in AI-supported learning environments to develop children's social skills. While AI is a tool that supports individualized learning, creating environments where children can develop social interaction skills is also important. AI-based games and simulations designed for group activities can support teamwork and cooperation, helping children learn collaboratively (Chen et al., 2019). Such applications will not only support individual learning but also enhance social learning processes for children.

The fourth recommendation involves making AI-supported learning tools suitable for children's age and developmental levels in terms of content and functionality. In preschool, considering children's cognitive development levels is essential when designing AI-based applications. Providing content appropriate to children's ages will make their participation in learning processes more effective and improve their understanding of scientific concepts (Cheng and Tsai, 2013). Thus, it is important for AI developers to adapt educational content according to children's developmental needs.

Finally, it is recommended to establish continuous research and feedback mechanisms to assess and improve the impacts of AI on education. Collecting more data on how AI-supported learning environments affect children's academic and social development can guide the future use of these technologies. Regular evaluation of AI's effectiveness by educational institutions and continuous adjustments based on children's needs are essential (Baker and Smith, 2019). In this context, ongoing research and new strategies should be developed to maximize AI's role in preschool science education.

8. References

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