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Impact of Artificial Intelligence and Robotics on Early Childhood Education: A Framework-Based Approach Utilizing the Five Big Ideas Model(*)

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Abstract

This paper aims at presenting an adapted framework based on the five big ideas, specifically designed to teach young children about artificial intelligence (AI) through the use of robotics. This study investigates the proposed system which emphasizes the utilize of mechanical autonomy and play-based learning to create AI available and empower engagement among youthful children who have not begun formal tutoring. In November (2022), the public release of (ChatGPT-3.5), a generative pre-trained transformer AI chatbot developed by OpenAI, made generative artificial intelligence widely accessible, requiring only an internet connection and a smartphone or computer. As a result, generative AI, particularly versions (ChatGPT-3.5) and -(4), experienced a notable increase in usage, prompting extensive discussions regarding its sustainable integration across diverse sectors, including education at all levels, from primary schools to universities. However, practical testing and evaluation in Early Childhood education are still relatively unexplored. The researcher has followed a comparative and analytical approach to figure out the similarities and differences in AI concepts between the original (K-12) educational system and the newly redesigned early childhood education framework. To provoke children intrigued, key concepts are displayed through intelligent with mechanical technology and robot role-play. This study has concluded that there are various advantages of introducing AI topics to young children, including enhanced creativity, theory of mind skills, and knowledge of AI. This paper too gives suggestions for age-appropriate points, narrating, and play-based instructing strategies. This system points to prepare analysts and teachers with procedures for effectively coordination initial AI instruction into early childhood classrooms. Educating AI in a formatively responsive way can offer assistance sustain youthful children's interest toward and understanding of a progressively AI-driven world.

Keywords: Artificial Intelligence (AI), Early childhood education, five big ideas of AI, framework.

Introduction:

AI includes creating computer frameworks that can perform assignments that would regularly require human insights, such as issue fathoming, learning, and choice making (Nilsson, 2010). Mechanical technology centers on planning and making physical machines competent of associated-ing with their environment and performing particular errands (Nilsson, 2010).

AI has recently emerged as a significant research topic and policy agenda. The emerge of AI and robots has garnered substantial attention from researchers, policymakers, and industrial leaders worldwide. AI is already central to children's digital environment, through recommendation algorithms or automated decision-making systems, for example.

Generative AI will no question take an indeed more noteworthy hold of their advanced encounters, and at a fast pace. To begin with, it is being implanted as chatbots, advanced associates, individual collaborators and look motors into computer program and apps as of now utilized by children.

Snapchat presented an 'AI friend' chatbot to its 375 million day by day dynamic clients. In spite of the fact that intuitively robots or AI-powered learning stages can improve learning encounters, adjust to person needs, and make instruction more pleasant and intuitively, substance systems for age-appropriate learning exercises for youthful children to memorize AI are missing.

Significance of the Study:

This study is of great significance for those who are interested in AI. The study is of great significance while teaching young children using enhanced creativity, theory of mind skills, and knowledge of AI. AI has become an imperative aptitude within the quickly advancing advanced society (Ng et al., 2021; Su, Ng et al., 2023). Typically, particularly genuine given that AI applications such as ChatGPT have illustrated their control as early as 2023 (Su & Yang, 2023c). Instructors are endeavoring to present AI into early childhood instruction to prepare understudies with the computerized abilities required for learning and living in today's computerized world (Joined together Countries Instructive, Logical and Social Organization [UNESCO], 2022). With the development of various AI-driven applications and virtual colleagues, such as Siri, Google Right hand, and ChatGPT, the request for AI instruction is expanding. AI literacy encompasses not as It

were a get a handle on of the specialized perspectives but too an understanding of AI's effect on society, the economy, and person lives, as well as how to successfully associated with and apply these innovations.

Earlier considers have appeared that AI courses can improve students' AI proficiency (e.g. Kandlhofer et al., 2016; Williams et al., 2019). In later a long time, different age-appropriate AI apparatuses and stages such as WeChat inaccessible control (Nan, 2020), Open to instruction Machine (Vartiainen et al., 2020), Zhorai (Lin et al., 2020), and PopBots (Williams et al., 2019) have been outlined to permit youthful learners to encounter and learn essential AI concepts. As of late, researchers have proposed that AI ought to be introduced in the early a long time of instruction, permitting children to adjust to the world of AI and utilize related applications (e.g., Fast, Draw!, AI for Seas, and Open to instruction Machine) to way better encourage their learning and way of life (Su & Yang, 2023).

Objectives of the Study:

This paper aims at:

1- Presenting the effect of an adapted framework based on the five big ideas on teaching young children via artificial intelligence (AI) through the use of robotics.
2- Investigating the use of the proposed system of five big ideas on the mechanical autonomy and play-based learning to create AI available and empowering engagement among youthful children.

Questions of the Study:

1- What is the effect of an adapted framework based on the five big ideas, on teaching young children via artificial intelligence (AI) through the use of robotics?
2- What is the use of the proposed system of five big ideas on the mechanical autonomy and play-based learning to create AI available and empowering engagement among youthful children?

Review of Previous Studies:

Robots for Early childhood:

In their (2022) review, Su and Yang found that playful robots are commonly utilized in early childhood education. Smart toys for learning, like programming robots and artificial intelligence games, offer kids a fun

way to enhance their theory of mind abilities and expand their views on robots and creativity (Su & Yang, 2023; Williams et al., 2019).

Five big ideas of AI for young children:

The AAAI and CSTA collaborated to form a joint working group tasked with creating national standards for teaching AI to K-12 students (Touretzky et al., 2019). The AI4K12 initiative created national standards for teaching artificial intelligence in K-12 education in 2018 (Touretzky et al., 2019).

AI4K12 (2020) created the five main concepts of AI for students in grades K-12, which include perception, representation and reasoning, learning, natural interaction, and societal impact. The phrase "big ideas" describes fundamental concepts or key principles that act as foundational pillars in a specific field or domain (The Early Math Collaborative of Erikson Institute, 2013). These concepts represent the fundamental principles, theories, and frameworks necessary for comprehending and progressing knowledge in the field. Large concepts frequently encompassing wide relevance and importance, serving as a structure for organizing and understanding intricate data and occurrences in a particular field (The Early Math Collaborative of Erikson Institute, 2013). Within the realm of AI, the five major concepts outline is a collection of essential ideas or principles that aid in visualizing and comprehending the core elements of AI and its diverse components and uses. Nevertheless, the current five major concepts of AI (AI4K12, 2020) may not be appropriate for kids between (2) and (6) years old.

The "Five Big Ideas" framework:

The "Five Big Ideas" framework in the context of Artificial Intelligence (AI) refers to a set of core concepts that are essential for understanding the fundamental principles and components of AI and its diverse applications. However, the existing framework of the Five Big Ideas of AI (AI4K12, 2020) may not be appropriate for children aged (2-6) years. To address this gap, the current study proposes a revised set of five AI-related ideas, specifically designed for preschoolers, with the intention of adapting them to be suitable for all stages of early childhood development.

This conceptual paper seeks to adapt the Five Big Ideas of AI for the context of early childhood education. The proposed framework not only redefines these five ideas but also aligns them with robotic activities that are

applicable to young children. Consequently, this study has developed an updated version of the Five Big Ideas of AI framework, specifically tailored to meet the developmental needs of young children (Figure 1).

Big AI idea (1) Perception:

Perception refers to the process of interpreting sensory inputs to gain meaningful insights (Touretzky et al., 2019). Enabling computers to possess functional visual and auditory abilities for real-world applications represents a significant achievement in the field of AI. Children can engage with AI by exploring its capabilities through their own sensory modalities, including sight, hearing, touch, taste, and smell. Encouraging children to interact with the sensory aspects of AI can help enhance their interest, understanding, and abilities, empowering them to better adjust to the developments in today's technological society. It is important for young children to be aware of the existence of AI and to learn how to engage with digital assistants like Siri. In addition, they have the ability to identify objects in their environment using sound. For instance, they are able to recognize the voices of their parents or caregivers and understand what they are saying.

1-Perception	**Activity Example: Robot senses Exploration**
AI systems use sensors to understand the world around them.	
2-Representation & Reasoning	**Activity Example: Shape sporting with robot friend.**
AI systems use rules and algorithms to process and analyze information.	
3-Learning	**Activity Example: Robot Dance Teacher**
AI systems can process a large amount of dataand learn from itto provide solutions.	
4-Natural Interaction	**Activity Example: Talking to storytelling Robot**
AI systems can interact with humans in ways that seem natural.	
5-Social Impact	**Activity Example: Robot Helpers in our City**
AI systems will produce impacts on human lives and the world.	

Figure (1) The five big ideas of AI for young children

For young children, the "perception" big idea of AI refers to the way AI systems use input data and predefined rules to make decisions. This illustrates how AI systems rely on sensors to interpret their surroundings

and make choices based on the information they receive. In essence, this represents the process of perception within AI.

Big AI idea (2) Representation and reasoning:

Young children can grasp that AI operates through representations that differ from human cognitive processes and reasoning. For instance, consider teaching a robot to recognize various animals. The robot is exposed to images of cats, dogs, and birds, each associated with a specific code-a pattern of numbers and symbols that represent the animals' features. The robot learns to link these codes to particular animals. When presented with a new image, the robot compares its code with previously learned codes, allowing it to identify whether the animal in the image is a cat, dog, or bird. Human understanding, however, relies on sensory input-such as sight and hearing-along with accumulated experiences. For example, upon seeing a ball, a person instantly recognizes it based on prior experience, without needing any specific codes or patterns. This recognition is rooted in memory and learned experiences over time. This recognition is rooted in memory and learned experiences over time. While the way AI understands the world may appear distinct from human cognition, it is nonetheless an effective tool for solving complex problems and fostering innovation. In this context, the concept of "representation and reasoning" in AI can be understood by young children as the recognition that AI operates differently from human thought processes. Unlike humans, AI does not possess conscious thought or life-like qualities. Instead, it relies on algorithms and rules to process and analyze information. This form of representation and reasoning is fundamentally distinct from the ways humans think and reason.

Big AI idea (3) Learning:

It is important for young children to recognize that AI has inherent limitations and may face challenges when confronted with unfamiliar situations it cannot address. For instance, the following activities can effectively facilitate the achievement of this learning objective.

The activity begins by placing several small toys on a table, and the teacher invites the preschoolers to wear blindfolds, simulating the role of AI robots in a game called "Treasure Hunt in the Dark." The preschoolers listen to the teacher's instructions and take appropriate actions to locate the toys. This game is repeated 5–6 times. Second, the teacher adjusts the game

according to the children's physical state and emotional responses. At a certain point, the teacher halts the instructions to observe whether the children can independently locate the toys. Third, the teacher joins in reflection. This highlights that when a robot encounters novel situations it has not been programmed to handle, unforeseen challenges may arise. This underscores the importance of continuous technological updates to improve AI's functionality and effectiveness. Young children should also develop an understanding that AI reaches accurate outcomes by identifying key elements and synthesizing information. One way to illustrate this concept is through a role-playing activity flow. Initially, preschoolers assume the role of AI robots. The teacher presents images of various colored fruits and asks, "Are they the same? What differences can you identify?" The preschoolers observe that the fruits vary in color. Second, the preschoolers continue their role-playing as AI robots, this time being shown images of differently colored vegetables. The teacher prompts, "Here are vegetables of different colors. What colors do you see? Who can help classify them by color?" The preschoolers correctly categorize the vegetables as instructed. Third, the preschoolers continue role-playing as AI robots while being presented with mixed images of fruits and vegetables. The teacher guides them to carefully listen for cues such as "red fruits," "red vegetables," and "red fruits and vegetables," prompting them to sort the image cards accordingly. Finally, the teacher determines when to conclude the activity based on the children's progress. The teacher emphasizes that AI systems must extract key, comprehensive information in order to arrive at a correct result, and that successfully completing the task requires careful listening and precise execution.

For young children, the "learning" big idea of AI pertains to its ability to support individuals in addressing complex problems. AI systems have the ability to handle and evaluate large volumes of data, allowing them to produce effective solutions. For example, through its learning abilities, AI can assist climate scientists in forecasting weather patterns and support medical professionals in diagnosing diseases.

Big AI idea (4) Natural interaction:

It is essential for young children to understand AI robots within their social context and recognize that these robots learn through interactions with

humans. By observing AI robots in settings where they engage with and learn from humans, children encounter a technology that emulates human communication. These interactions may involve activities such as storytelling, games, and collaborative tasks, all of which promote a sense of companionship and mutual understanding between children and robots. As AI robots engage with children, they can adjust their responses and behaviors based on the children's input, much like how humans modify their communication styles when interacting with different individuals. This adaptability not only strengthens the child-robot relationship but also supports the development of the children's social and cognitive skills (Tazume et al., 2020). In conclusion, integrating AI robots into young children's social contexts holds significant potential for fostering holistic development. By replicating human communication and tailoring interactions to individuals, these robots can offer personalized and engaging learning experiences. As children form meaningful connections with AI robots, they enhance not only their social and cognitive abilities but also their language skills.

For young children, the "natural interaction" big idea of AI refers to the fact that AI pertains to the understanding that AI is a human-made tool. While AI systems are capable of engaging with humans in ways that may appear natural, such as through conversation, it is crucial to recognize that these systems are designed by humans and lack consciousness or self-awareness.

Big AI idea (5) Societal impact:

AI has the capacity to both positively and negatively impact society (AI4K12, 2020). While AI is driving significant changes in various domains such as employment, transportation, and communication, it also carries the potential for adverse consequences (Ng et al., 2021). One of the key ethical issues surrounding AI is its responsible application, particularly concerning data privacy and algorithmic bias. AI systems can unintentionally reinforce existing biases present in the training data, resulting in outcomes that are unfair or discriminatory (Martin et al., 2022).

It is essential for young children to develop an understanding of the role AI plays in their daily lives and its potential future contributions. One effective approach to fostering this understanding is through storytelling (e.g., AI Robotic Story; Su & Yang, 2023b). By engaging with relevant

narratives, children can gain insight into the ways AI influences their routine activities and explore the possible advancements it may facilitate in the future.

Storytelling, as an educational strategy, enables students to engage deeply with scenarios, fostering the development of positive attitudes and interest in AI and robotics.

For young children, the "societal impact" big idea of AI involves early exposure to technology, computers, coding, and AI, with an emphasis on understanding how these innovations will shape human lives and the broader world. Gaining an understanding of AI and its potential consequences from a young age can empower students to engage with this technology in a responsible and productive manner, ultimately enabling them to make positive contributions to society.

A comparative analysis Applying the five big ideas of AI to K-12 in ECE:

As shown above, although the five big ideas of AI for early childhood education framework aims to integrate AI concepts into KG education (AI4K12, 2020), the framework can also be useful in the early childhood education context, provided changes are made to increase its suitability to younger children's learning experiences and abilities. This is mainly because the way these concepts should be presented and taught would differ between KG education and early childhood education contexts. For instance, in KG education, concepts might be taught in a more abstract and theoretical manner, whereas in early childhood education contexts, they are likely to be introduced through play-based and hands-on activities (Inan & Inan, 2015).

Table 1 shows the commonalities and differences in AI big ideas between the original KG framework and the reshaped early childhood contexts framework.

The ECE context primarily focuses on children from birth to around eight years of age (Bijou, 1976). Modifications are made to ensure that the AI framework aligns with the developmental stages and needs of young children. The language and concepts are simplified to be accessible to early learners, recognizing the distinct cognitive capacities of younger children compared to older students (Bijou, 1976). These adjustments are designed to

present AI concepts in a manner that is developmentally appropriate, promoting better understanding and engagement with AI-related subjects. The overall aim is to enhance the learning experience by making it more interactive and engaging for young children.

Table (1) The commonalities between the two frameworks

	AI big ideas for KG	AI big ideas for early childhood
Big Idea (1) Perception	**Computers perceive the world using sensors.**	**AI systems use sensors to understand the world around them.**
Big Idea (2) Representation and Reasoning	**Agents maintain representations of the world and use them for reasoning.**	**AI systems use rules and algorithms to process and analyze information.**
Big Idea (3) Learning	**Computers can learn from data.**	**AI systems can process a large amount of data and learn from it to provide solutions.**
Big Idea (4) Natural Interaction	**Intelligent agents require many kinds of knowledge to interact naturally with humans.**	**AI systems can interact with humans in ways that seem natural.**
Big Idea (5) Societal Impact	**AI can impact society in both positive and negative ways.**	**AI systems will produce impacts on human lives and the world.**

As presented in Table (1) both frameworks share common elements, including the acknowledgment of perception, learning, and the societal impact of AI. However, the key differences are found in the emphasis placed on representation and reasoning, as well as the approach to understanding natural interactions within AI systems. The shared aspects between the AI big ideas in the original KG framework and the redesigned early childhood framework are as follows:

1- Perception: Both frameworks emphasize the significance of computers and AI systems in their ability to perceive and interpret the surrounding environment. They highlight the crucial role of sensors in facilitating the capacity of these systems to comprehend and interact with their surroundings.

2- Learning: Both frameworks highlight the capacity of computers and AI systems to learn from data. They acknowledge that these systems can process vast amounts of information, utilizing the data to enhance learning and generate solutions.

3- Societal Impact: Both frameworks recognize that AI has the potential to produce both beneficial and detrimental effects on society. They acknowledge that AI systems can influence human lives and the world.

However, there are several important distinctions between the two frameworks.

1- Representation and reasoning: In the original K-12 framework, agents (computers or AI systems) maintain representations of the world and use them for reasoning. In contrast, the redesigned early childhood framework states that AI systems use rules and algorithms to process and analyze information. The original framework prioritizes the preservation of representations, while the revised framework places greater emphasis on the application of rules and algorithms for processing and analyzing information.

2- Natural interaction: In the original KG framework, intelligent agents require many types of knowledge to interact naturally with humans. However, the remodeled early childhood framework highlights that AI systems can interact with humans in ways that appear natural. Although both frameworks recognize the importance of natural interaction, the original framework focuses on the knowledge required for natural interaction, whereas the redeveloped framework emphasizes AI systems' ability to interact naturally.

Using robotics to engage young children in learning the five big ideas of AI:

A comprehensive outline of AI robotics activities, specifically designed to support young children's understanding of the five big ideas of AI, is provided in Table (2) These activities aim to actively involve young children in a playful and interactive manner, facilitating their introduction to the big ideas of AI. Through hands-on exploration, creativity, and discussions, the activities are structured to promote a foundational understanding of AI concepts.

Table (2) AI robots' activities based on the five big ideas framework

Five big ideas of AI	Robotics activity	Details
Perception	Activity (I) Robot Senses Exploration	Introduce the concept of how robotics perceive the world through their senses. -Use a simple robotic toy with sounds and movement. -Let children take turns listening and observing the robot's reactions. -Explain that robots have sensors that function like ears and touch, just like how people sense things.
Representation &Reasoning	Activity (2) Shape Sorting with a Robot Friend	Provide colorful shapes and a friendly robotic toy. -Have children place different shapes in front of the robotic toy and ask it to sort them. -Discuss how the robotic toy identifies each shape and decides where to place it based on its features.
Learning	Activity (3) Robotic Dance teacher	-Show a dancing robotic toy that can learn and repeat dance moves. -Guide children in teaching the robotic toy simple dance steps by demonstrating and letting them try. -Emphasize how the robotic toy learns from watching and imitating, just like how kids learn from watching others.
Natural Interaction	Activity (4) Storytelling Robot Toy	-Introduce a storytelling robotic toy or voice-controlled assistant. -Encourage children to ask the robotic toy questions or request a story. -Show how the robotic toy responds to their words, highlighting that they can talk to robotics like talking friends.
Societal Impact	Activity (5) Robot helpers in our city	-Set up a miniature city with various scenarios where robots help people. -Let children roleplay as both people and robotics, demonstrating how robotics can assist with everyday tasks. -Hold discussions about how robotics can improve life for everyone.

Table (2) presents a summary of AI robotics activities structured around the five big AI ideas framework. These activities are designed to familiarize children with various aspects of AI and robotics, including perception, representation and reasoning, learning, natural interaction, and societal impact. Through interactive experiences with robotic toys-such as exploring sensors, sorting shapes, teaching dance moves, participating in conversations, and simulating robot-assisted scenarios-children can gain insights into how robots perceive, reason, learn, interact, and contribute to society. These activities offer hands-on opportunities that enable children to better understand and appreciate the capabilities and potential societal implications of AI systems.

Conclusions and Recommendations:

Recent research has highlighted the various advantages of introducing AI topics to young children, including enhanced creativity, theory of mind skills, and knowledge of AI. However, several early childhood educators face challenges in teaching AI and often lack the confidence to deliver AI lessons. To address this gap, the present study introduced a framework based on the five big ideas of AI framework, specifically designed for early childhood education. Additionally, it proposed strategies for utilizing robots as a technological tool to actively involve young children in learning the five big ideas of AI. Introducing AI in early childhood can help children develop a foundational understanding of AI and its applications, thereby preparing them for more advanced learning opportunities and laying the groundwork for future engagement with science, technology, engineering, and mathematics education.

Based on the five big ideas framework, we advocate for an interdisciplinary approach that merges storytelling with play-based learning to address core AIR issues. The storytelling approach facilitates integrated learning by creating narratives that link content and activities across subjects. AI lessons can be embedded within engaging stories that highlight real-world AI applications, thus providing a meaningful context for learning. Play-based learning, which promotes active learning through games and hands-on activities, is particularly beneficial for young learners. For instance, role-playing AI robots offers children the opportunity to explore the functionality of AI through play.

In the context of today's technologically advanced world, young children are increasingly exposed to AI systems and technologies. The proposed modifications to the early childhood education framework aim to introduce children to AI concepts and terminology, fostering a foundational understanding of AI and its applications in daily life. This initiative is intended to promote digital literacy and encourage the responsible use of AI technologies from an early age. Future research should focus on adapting and applying the five big ideas of AI for KG in early childhood education in a manner that is both developmentally appropriate and engaging for young learners, particularly through child-robot interactions. To apply the five big ideas framework in early childhood classrooms we, recommend focusing on AI topics that are directly relevant to the children's experiences, such as conversational interactions with robots and facial recognition. The framework offers guidance on age-appropriate content, while storytelling and play-based learning methods support a deeper understanding. With a well-considered approach, AI education can be made accessible, meaningful, and enjoyable for young learners.

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