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Artificial Intelligence (AI) in Early Childhood Education: Curriculum Design and Future Directions

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Abstract: Nowadays, with the rapid development of technology brought about by AI, the demand for AI talents in the future is increasing. It is crucial to cultivate the next generation's AI capabilities and teach them how to face AI and use AI. In the past, AI research has mainly focused on primary and secondary schools colleges, and universities, but the curriculum on AI for early childhood education is still rare. Due to the lack of AI curriculum standardization in early childhood education - to the problem that there is no uniform standard for AI curriculum standardization in the early childhood education stage in China, the article applies a framework consisting of four parts, namely, (1) teaching objectives, (2) teaching content, (3) teaching methods, (step) teaching evaluation and (4) teaching assessment, to study the kindergarten early childhood AI curriculum. Artificial intelligence literacy is achieved through three competencies: Al knowledge, Al skills, and AI attitudes.

Keywords: Early childhood education ; Artificial intelligence ; Kindergarten AI ; Curriculum design

1. Introduction

1.1 Artificial Intelligence

Artificial intelligence (AI) refers to "the science and engineering of creating intelligent machines". Artificial Intelligence (Al) is a branch of computer science, which integrates a variety of technologies such as machine learning, algorithm development, and natural language processing. Research in artificial intelligence has been concentrated at the secondary and tertiary levels, with relatively little research at the kindergarten level. As society continues to advance, the younger generation of families have smart homes and smartphones, and children have access to tablets and smart toy interactions in their first year of life. Recently, there has been a growing body of research related to early AI education for young children. For example, knowledge-based systems, supervised machines, and generative AI can be used to introduce young children to AI concepts. However, the existing literature on AI in early childhood education is not sufficiently researched in the curriculum, and there is a big difference between kindergarten AI and secondary and tertiary AI.

1.2 Kindergarten AI

AI in kindergarten and AI in secondary and higher education are very different. Kindergarten AI focuses on basic concepts and simple AI activities (e.g., concept mapping, AI frameworks, etc.). However secondary and tertiary AI focuses more on programming as well as complex concepts. There are many aspects of learning AI for kindergarten children, such as children's AI activities that enhance both computational thinking and problem-solving skills as well as promote children's AI knowledge. In addition, children's interaction with AI enhances creative inquiry, affective inquiry, and collaborative inquiry.Therefore, we strongly suggest that kindergarten children learn AI.

1.3 Curriculum

Curriculum refers to "the sum total of all direct and indirect experiences, activities, and events that take place in an environment and are designed to encourage children's learning and development". A curriculum can be divided into four areas: goals or objectives, content or subject matter, methods or procedures, and evaluation and assessment. Many academics believe that the recognition of quality early childhood education has a positive effect on either early childhood educational achievement or on the relationship between young children and their teachers, and in order to ensure the quality of quality early childhood education, governments and

policymakers have begun to introduce computational thinking into the earliest grades of the curriculum. Numerous studies have confirmed that the use of coding or programming apps can help develop children's computational thinking skills as well as their ability to reason and communicate in an increasingly rich digital world. Despite the fact that early research in AI benefits children's cognition, intelligence, and social interactions, we have yet to discover strategies that are appropriate for children's AI education and learning. For this reason, the authors propose a pedagogical strategy based on problem-based learning, which improves children's ability to apply critical thinking to problem-solving and cooperation.

2. Background

Existing guidelines for AI education

As artificial intelligence (AI) becomes more prevalent in society, there will be a greater demand for AI-literate workers in the future. As Our society faces major public policy issues involving AI technologies, informed citizens are required to comprehend the fundamentals of AI. To prepare children with competencies to face the rapidly transforming and tech-driven world and help them ensure their employability and career potential in the future (Preface, 2021),children must be sufficiently educated to work with and use AI (Touretzky et al., 2017)[1]. Countries such as China, the United Kingdom, Thailand, Korea, and the European Union are making strides in AI education to standardize what students should learn at various levels. Many groups have created criteria for teaching AI to students in grades K through 12. The Associaction for the Advancement of Artificial Intelligence (AAAI) and the Computer Science Teachers Association (CSTA) launched a joint working group in May 2018 to create national guidelines for teaching artistsfacial intelligence to K-12 students (AAAI, 2018)[2]. In line with the CSA's national standards for K-12 computer education (CSTA, 2017)[3], the AI for K-12 recommendations (ai4k12.org) established what students in each grade band should know about artificial intelligence, machine learning, and robotics.

Among the organizations, AI4K12 proposed the Five Big Ideas framework, which includes Perception, Representation and Reasoning, Learning, Natural Interaction, and Societal Impact, to cover the breadth of the area and make it approachable for teachers. The framework not only includes definitions and examples for each principle, but it also goes into greater detail about what K12 students should perform in each category. For example, the first concept is Perception, which refers to the process of extracting meaning from sensory inputs. It contains speech recognition, computer vision (e.g., object detection, face recognation, license plate readers, and scene understanding), and other forms of perception (e.g., music recognition, or interpreting sonar, radar, or LIDAR data). The framework also explains what K-12 students must do in the category of concepts. Students in grades K-12, for example, learn to recognize sensors on computers, robotics, and smart appliances, as well as engage with intelligent agents like Alexa or Siri. Students in grades 3–5 must explain how sensor inputs are translated to analog or digital signals, demonstrate a computer perception constraint, and create an application using perception (possibly with Scratch plugins, or Calypso). Students in grades 6–8 must explain how sensor constraints affect computer perception, describe how perception systems use numerous algorithms and many sensors, and create an application that uses multiple sensors and forms of perception (possibly with Scratch plugins, or Calypso). Students in grades 9–12 must describe the domain knowledge that underpins various forms of computer perception and demonstrate speech recognition difficulty while dealing with homophones and other types of ambiguity. The framework provides considerations for students' activities as well as relevant learning tools to help AI education.

2.1 Kindergarten AI Curriculum

Artificial Intelligence education moves away from computational thinking to discuss computer perception, thinking behavior, learning, decision-making, creative perception, and cognition. Younger children are specific thinkers, and active learners, and particularly benefit from a hands-on approach to STEM. Research shows that 3-year-olds are better able to explore AI in a simple, basic way. Children are fast learners and curious, and using appropriate pathways and resources to investigate AI facilitates children's identification of AI technology in everyday life, enables children to gain programming skills to apply that technology to the real world, and to become aware of the ethical issues that can result from the use of AI technology. Therefore, they summarised three competencies for achieving AI literacy, namely AI knowledge, AI skills, and AI attitudes.

2.1.1 Knowledge of Al

The teaching of AI knowledge aims to help students understand the basic concepts of AI. The AI knowledge compendium is divided into five parts, covering 1. Meaning and types of AI; 2. Problem-solving and search; 3. Reasoning; 4. Data and machine learning; and 5. Applications. "Meaning and types of artificial intelligence" refers to the main understanding of the difference between artificial intelligence-based systems and algorithm-based systems; "problem solving and searching" refers to proficiency in searching techniques; the so-called "reasoning" refers to learning systems that can simulate human intelligence. The term "reasoning" refers to learning computer models that can simulate human thought; "data and algorithms" refers to the understanding of machine learning

algorithms and the detection of data patterns. "Application" refers to having subjects try and learn speech recognition, optical text recognition, and other common AI techniques.

2.1.2 AI skills

Students with AI skills can use their programming skills to think computationally, as Kim and others (2021)[4] have demonstrated. Artificial intelligence can help us deal with a wide range of complex puzzles. "Using AI tools" and "computational thinking and programming" are two combinations of AI skills. Using AI tools means using appropriate AI tools for problem-solving; while computational thinking development and programming is about building a simple AI application to enhance students' computational thinking. computational thinking as described by Wina (2006)[5] represents students' ability to solve problems based on computer science and understand human behavior, computational thinking focuses on many levels of abstraction to develop critical analysis skills, computational thinking is considered one of the indispensable skills for students as AI experts (Kim et al., 2021)[4].

2.2 Tools and resources for AI at the kindergarten level

At the kindergarten level, we can start to introduce children to some AI concepts such as robotics, drones, virtual assistants, AI vision, etc. In this stage, certain tools and resources can be provided for children's learning, mainly as follows:

1.Picture books and stories: Tell children stories to let them know what artificial intelligence means.

2.Songs and music: Let children get to know artificial intelligence through music.

3. Physical models: Using some physical models, children can understand what artificial intelligence is more deeply.

4. Cartoons: Make children understand artificial intelligence through several cartoon images.

5. Toys and games: use them to make children feel the connotation of artificial intelligence.

In addition to these tools and platforms, Weintrop et al. (2016) drew on three resources for the creation and validation of the taxonomy of computational thinking in mathematics and science, including (1) educational activities in mathematics and science, (2) existing concept inventories and standards documents, and (3) interviews with Mathemagicians and science. Winthrop et al. (2016) further broke the taxonmy into four categories, 1) involving data practices collecting, creating, manipulating, analyzing, and visualizing data), 2) modeling and simulation practices (i.e., using models to understand a concept, find and test solutions, and assessing, designing, and constructing computational models), 3) computational problem-solving practices (ie., preparing problems for computational solutions, programming, choosing effective computational tools, assessing different solutions.

Developing modular computational solutions, creating computational abstractions, and troubleshooting and debugging), and 4) systematic thinking (i.e., investigating a complex system as a whole, understanding the relationship within a system, thinking in levels, communicating information about a system, defining systems, and managing complexity). This study offered a range of useful resources for AI learning, which not only contributed to building the reciprocal relationship for learning between computational thinking and mathematics and science domains, but also helped address practical concerns in the fields.

3. Summary

This study designed a variety of AI curricula (concepts, pedagogical approaches), instructional activities, evaluation recommendations, and perspectives for educators. The purpose of this study was to develop an AI curriculum framework for early childhood education and to develop a curriculum that presents early childhood education. The curriculum was designed with three main components, AI knowledge, AI skills, and AI attitudes. The study provides three modules, five activities, and a project for children, which helps AI educators and researchers discover and develop a curriculum that is most suitable for children aged 5-7 years old, as well as helps researchers develop an early AI research design and a problem-based research teaching methodology suitable for pre-AI teaching.

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