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1 author:

Weipeng Yang
The Education University of Hong Kong
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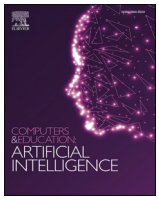

Artificial Intelligence education for young children: Why, what, and how in curriculum design and implementation☆

Weipeng Yang

Department of Early Childhood Education, The Education University of Hong Kong, Hong Kong Special Administrative Region of China

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ABSTRACT

Artificial intelligence (AI) education has posed fundamental challenges to early childhood education (ECE), including (1) *why* AI is necessary and appropriate for learning in the early years, (2) *what* is the subset of key AI ideas and concepts that can be learned by children, and (3) *how* to engage children in a meaningful experience that allows them to acquire these fundamental AI concepts. This report from the ECE field discusses the key considerations for developing an AI curriculum for young children. These key considerations altogether present an innovative pedagogical model for AI literacy education in early childhood. This model argues that AI literacy is an organic part of digital literacy for all citizens in an increasingly intelligent society. The core AI knowledge that can be explored with young children is: Using large amounts of data input, AI algorithms can be continuously trained to identify patterns, make predictions, and recommend actions, even though with limitations. Based on the theoretical notions of learning-by-making and pedagogy-*as*-relational, an embodied, culturally responsive approach should be used to enable young children's exploration with AI technologies. Finally, an exemplary curriculum named "AI for Kids" is introduced to demonstrate this pedagogical model and explain how educators can provide children culturally responsive inquiry opportunities to interact with and understand AI technologies. The synthesis of knowledge regarding "Why", "What", and "How" to do with AI education for young children informs a new way to engage children in STEM and understanding the digital world.

1. Introduction

Artificial Intelligence (AI) is accompanying a whole generation of children to grow up in a rapidly changing digital world, with the proliferation of virtual assistants such as Siri and Google Assistant and many other AI-enabled applications in all sorts of areas such as healthcare, automobile, education, social media, entertainment, and robotics (Druga et al., 2018; Su & Yang, 2022). AI is defined as the science and engineering of problem-solving with technological innovations such as machine learning and neural networks (Wang, 2020). It represents the integration of science, technology, engineering, and mathematics (STEM), which has been highlighted in the current technology-empowered society. AI education has posed fundamental challenges to early childhood education (ECE), including (1) *why* AI is necessary and appropriate for learning in the early years, (2) *what* is the subset of key AI ideas and concepts that can be learned by children, and (3) *how* to engage children in a playful and meaningful experience that would allow them to acquire these fundamental AI concepts (Sakulkueakulsuk et al., 2018).

AI education can integrate knowledge of different disciplines and multiple technologies simultaneously, and has a great potential to enrich children's learning. Previous evidence shows that AI-enabled interfaces support young children to access digital content and services via child-computer interactions such as gesture, touch, and speech (Williams et al., 2019). Preschool children's interactions with AI-interfaced toys or robots can improve their creativity, emotion, collaborative inquiry and related literacy skills (Kewalramani et al., 2021; Su & Yang, 2022). However, not much is known about how preschool teachers can intentionally support children's learning with and about AI technologies with a systematic and appropriate approach. As shown in a recent review (i.e., Su & Yang, 2022), there is a scarcity of research on AI education for young children who have no prior knowledge of computer programming and robotics.

In practice, there are an increasing number of resources and curricula for students to learn about AI. However, most of the existing AI education resources and programs target students in primary and secondary schools and above. It is rarely studied how to effectively design and implement AI curriculum that can help young non-programmers

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E-mail address: wyang@eduhk.hk.

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acquire AI literacy through age-appropriate learning content and approach. To address this knowledge gap and those fundamental challenges in AI education, this article draws upon an exploratory literature review to generate a list of key considerations and further inform curriculum design and implementation in ECE. These key considerations are structured with the three basic questions about curriculum development for young children aged 3–8 years – Why, what, and how (Bredekamp, 2020):

1. Why is AI education needed for young children?
2. What is appropriate to learn in AI education during the early years? What is the subset of key AI ideas and concepts (or "AI literacy") that can be learned by children?
3. How should young children learn about AI? In other words, what are the appropriate pedagogical approaches?

2. Why learning AI in the early years: digital equity for all

The idea of AI integration into ECE does not come without critique, although AI is all around us. To move beyond the debate about whether young children should learn about AI, an extensive body of literature has explicitly shown at least three strong reasons for learning AI in the early years.

First of all, knowing and understanding the basic functions of AI and using AI applications is an organic part of digital literacy for all citizens in an increasingly intelligent society (Ng et al., 2021). Against the context of democratizing AI for education (Druga et al., 2019), it is vital to develop learning activities that can scaffold young children's understanding of AI with the use of age-appropriate tools (e.g., AI-interfaced robots and applications) introducing machine learning models to children. Machine learning which enables computers to recognize patterns and make decisions without being directly programmed (Lane, 2021), is a major type of AI that needs to be focused on because of its power in shaping the human society. Due to the fact that we are embracing an AI-enabled era, we must ensure that all children and their families, especially those from less advantaged backgrounds, have access to digital literacy training, as well as the use of digital technologies, including AI technologies. Previous research has documented a greater digital divide (Daugherty et al., 2014; Judge et al., 2006), which has a negative impact on the field of AI technology. Children from less advantaged backgrounds may not have enough opportunities to develop a solid, fundamental understanding of AI. Druga et al. (2019) investigated how young children reported their AI perception and expectations and found that children from low social-economic status (SES) backgrounds would be difficult in advancing their use of AI-enabled devices due to their lack of experience interacting with these technologies. The digital divide has been transferred to the field of AI, resulting in an urgent need to promote AI for all children in classrooms and to achieve digital equity and the sustainable development goals in ECE.

Second, children need to be empowered to understand, use, and evaluate AI with purposeful guidance, which in turn would promote their interdisciplinary learning. Otherwise, they cannot acquire AI literacy through their own aimless exploration or free interaction with AI-enabled technologies or toys. In another word, they are not able to understand how AI-enabled devices work without effective guidance (Williams, Park, & Breazeal, 2019). Previous research shows that although children encounter AI in the forms of smart devices such as iPhones and social robots widely used in various environments and occasions, they are likely to lack the means to probe these computational objects through self-initiated interaction and exploration (Druga et al., 2017, 2018). In contrast, previous evidence shows that learning about AI can improve children's creativity and collaborative inquiry skills (Kewalramani et al., 2021), computational thinking (Vartiainen et al., 2020), and language skills and adaptive behaviors (Prentzas, 2013). This is because children's increased exposure to and understanding of AI will enable their reasoning about digital technologies be more nuanced (Druga et al., 2017; Severson & Carlson, 2010).

Third, children have the capability to understand the basic functions of AI, especially when they are provided with the learning opportunities that are age-appropriate and relevant to their prior experience. There seem to be a concern that young children may not be able to achieve a meaningful understanding of AI technologies. Instead of untrusting children's capability in learning with and about AI technologies, we need to scaffold children to "develop the agency to ask questions, inquire and manipulate AI toys safely and appropriately, within their playful interactions with their peers" (Kewalramani et al., 2021, p. 653). Only through introducing AI in an age-appropriate manner, children can acquire "a healthy appreciation for its [AI's] abilities and limitations and develop an appropriate relationship with it" (Williams et al., 2019, p. 9730). The research evidence also continues to indicate that children as young as four years old are able to use abstract concepts such as logical ordering and cause-effect relationship that are widely used in technological inquiries as part of digital literacy (e.g., Kazakoff et al., 2013; Kewalramani et al., 2021).

Learning AI in the early years requires efforts pursuing sustainable development that can help narrow down the digital divide in ECE, and achieve digital inclusion and digital equity in the long run (Berson et al., 2021). The agenda of promoting AI in ECE will also help establish a digital inclusion ecosystem that combines programs and policies to meet a community's diverse needs in digital access and use. However, there is a scarcity of research on the integration of AI in ECE, although we live in a rapidly changing digital world where AI is already a constant presence in our daily lives. Due to an absence of training and practical experience in this field, ECE teachers lack the skills to promote learning of AI technology by children. How to integrate AI literacy into early childhood curriculum is still rarely known.

3. What to learn: AI literacy for young children

AI education helps learners understand how computers sense, perceive, learn, make decisions, create, and act (Williams, Park, & Breazeal, 2019). As a subgroup of digital literacy, AI literacy has emerged as a new set of skills in response to the increasingly important role AI is playing in the daily lives of human beings, which can increase people's knowledge of AI technology and critical thinking and help them make discerning decisions. AI literacy can be defined as knowing and understanding the basic functions of AI and how to use AI applications in everyday life ethically (Druga et al., 2019; Rodríguez-García et al., 2020). It involves three key facets (Kandlhofer et al., 2016): (1) knowing that AI has been used to improve human's daily life; (2) computers can learn from data through classification, prediction and generation; and (3) understanding that AI should be used ethically to avoid bias. According to Ng et al.'s (2021) recent review of research, AI literacy can be classified into four aspects: knowing and understanding AI, using and applying AI, evaluating and creating AI, and AI ethics (p. 4).

Williams, Park, and Breazeal (2019) designed an AI-interfaced robot for young children to help them "gain a healthy appreciation for its abilities and limitations and develop an appropriate relationship with it" (p. 9730). They used the robot to teach three AI concepts, including knowledge-based systems, supervised machine learning, and generative AI (See Table 1). However, it is unclear why these three AI concepts are taught to young children.

As interplayed with the conceptualization of computational thinking (Brennan & Resnick, 2012), a more comprehensive framework proposed in Ng et al.'s (2021) AI literacy review can be useful for identifying the subset of key AI concepts, practices, and perspectives. Table 2 shows the specific elements which can be the focus of AI education for young children.

Furthermore, AI literacy can be embedded in well-designed robots or other intelligent agents. Fig. 1 shows the role of intelligent agents or AI educational tools in creating, testing, or demonstrating machine learning models. Machine learning models explicitly represent the

Table 1
Three AI concepts for young children.

AI concepts	Descriptions	Activities
Knowledge-based systems	How AI robots can learn; how to use AI robots to make predictions	Children teach the AI robot the three rules of Rock-Paper-Scissors game on the programming interface of a tablet. Children can teach correct and incorrect rules to the robot. After that, they can play the game against the robot. The robot can guess for a move.
Supervised machine learning	How AI robots can learn patterns based on a training set	Children teach the AI robot to classify healthy and unhealthy foods based on several features such as color. They can also program the robot how to respond to the foods. After that, the robot guesses the group of a food.
Generative AI	AI robots not always following rules	Children teach the AI robot musical emotions using the programming interface. Then, children play music to the robot, and the robot plays back a remix.

Source. Williams, Park, and Breazeal (2019).

process of training AI-powered technologies. To help young children learn about AI, for instance, Williams, Park, and Breazeal (2019) used a social robot called 'PopBots' to make AI concepts accessible. The social robot was used as an intelligent agent and a learning companion for children ages 4–7 years to program and train, thus learning AI literacy. Three hands-on activities were developed to engage young children in interacting with the social robot, with a focus on knowledge-based systems, supervised machine learning, and generative algorithms respectively (Williams, Park, & Breazeal, 2019). However, the PopBots platform is not made available to the public for wider use and testing. Therefore, it is practically significant and impactful to use a freely available agent/system and design an AI literacy curriculum for young children. Some of these publicly accessible intelligent agents such as *Quick, Draw!* and *Teachable Machine* can be used for the development of AI literacy curriculum to be used in ECE settings. Druga et al. (2019) suggests that physical tinkering and learning activities can be designed to help children understand how the intelligent agent (e.g., a robot) can perceive and make sense of the problem. The key to achieve this goal is to make the intelligent agent perform a transparent process of AI reasoning, so that children can better understand AI practices.

However, how to promote AI literacy for young children remains underexplored. Children seem to lack a clear understanding of how AI technologies such as smart toys work (McReynolds et al., 2017), possibly due to a lack of scaffolding from more knowledgeable others (Vygotsky, 1978). Therefore, the following section details how to introduce AI to children in a developmentally and culturally appropriate manner.

4. How to learn: introducing AI to children through an embodied and culturally responsive pedagogy

Researchers assert that the lack of embodied, multimodal learning in STEM education will limit individuals' capacity to aspire toward a digital future that requires creative inquiry and higher-level thinking skills (Turner & Griffin, 2021). AI education is closely related to STEM education requiring creative exploration so that children can be motivated to make something personally relevant and meaningful. For instance, Sakulkueakulsuk et al. (2018) connect AI with STEM to promote project-based learning, passion, play, and peer learning in an AI-based learning activity. Different from the group of traditional STEM subjects which is stereotyped to be a white male property, embodied pedagogy demonstrates how STEM trajectories can be built for all children to achieve positive learning and development in the early years.

4.1. Embodied instruction in AI education

Based on the theory of embodied learning which aligns with broader theories of constructionism (Papert, 1980, 1993) and sociocultural learning (Vygotsky, 1978), an AI literacy curriculum enriched with embodied learning activities will help children acquire the powerful ideas of machine learning and ethics related to AI application (e.g., AI

Table 2
A framework of the elaborated elements of AI literacy for young children.

Elements	Descriptions	Examples
AI concepts	Technical and conceptual understanding of the basic functions of AI	Classification, prediction and generation
AI practices	The techniques and strategies used when applying AI	Training, validation and testing
AI perspectives	Attitudes and dispositions adopted while solving problems	Collaborating to solve problems, understanding of technology as a problem-solving tool

Note. This framework was proposed by Ng et al. (2021).

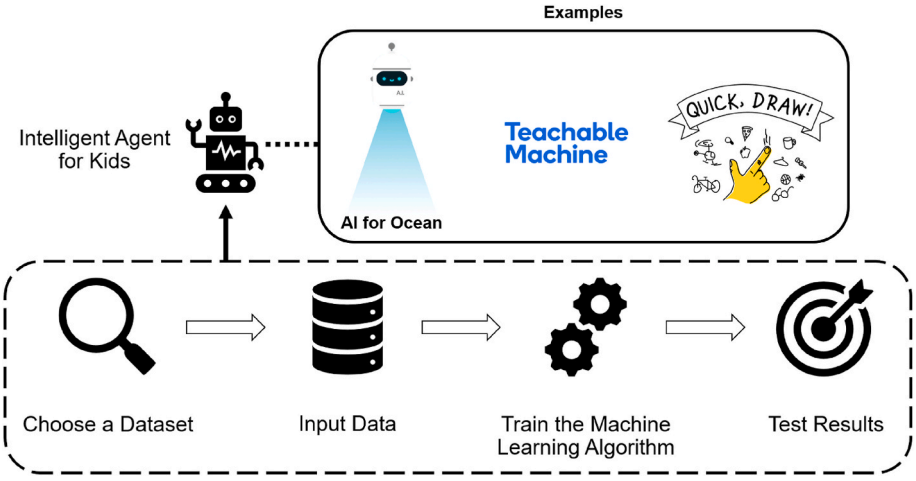

Fig. 1. Using intelligent agents to demonstrate the machine learning models to children.

bias). For example, Williams, Park, and Breazeal (2019) designed a social robot that can enable young children to interact with AI technology through hands-on experiences.

Informed by the progressive notions of learning-by-making (Papert, 1980, 1993) and pedagogy-*as*-relational (Vygotsky, 1978) which build upon the theories of constructionism and sociocultural learning, an AI literacy curriculum for young children should be situationally embodied. Such an embodied perspective advocates that any content to be learned should be related to a particular context that is relevant to learners' experience (Barab et al., 2007). The idea of situative embodiment suggests the curriculum to involve a storyline that provides a meaningful goal, expected actions, and a learning background for learners. Importantly, this kind of embodiment will provide a contextual framing that enables learners to appreciate the use-value of the curriculum content. For instance, the AI concepts will be embedded in a storyline that unfold when young children are developing a better understanding of AI technology. The embodied perspective will also encourage children to apply or transfer their understanding of AI to solve a problem or fix an error when testing a solution. Within such a framework of embodied curriculum, a young child participates in "a narrative context of use and, through it, engages a formalism as situationally embedded in, embodied by, or abstracted from the socio-material context" (Barab et al., 2007, p. 5). Wang and Zheng (2018) further clarify that the three key considerations for developing an embodied curriculum are: (1) relating to the real world of life and integrating the curricular narrative framework and students' learning trajectory; (2) introducing embodied experience to realize the ongoing interaction between the learners' body, mind, and environment; and (3) integrating technologies to provide a powerful intermediary tool for the curriculum. This framework informs the development of our AI embodied curriculum that is culturally sensitive for young children in Hong Kong (See the exemplar of *AI for Kids*).

4.2. Culturally responsive curriculum in AI education

AI education should respond to the social and cultural background of children to be meaningful and appropriate. Cultural responsiveness is the approach which recognizes the importance of using learners' cultural tools, resources, or experience as their strengths to empower and enable their learning (Villegas, 1991). A culturally responsive curriculum is able to embrace diversity and inclusivity in teaching and learning various subjects, including STEM and AI literacy. Therefore, cultural responsiveness serves as a medium to strengthen learners' sense of identity in approaching AI, engage learners in curriculum decision-making, and promote equity, inclusivity and diversity in the classroom. As quoted in Hammond (2014, p. vii),

> Cultural responsiveness is not a practice; it's what informs our practice so we can make better teaching choices for eliciting, engaging, motivating, supporting, and expanding the intellectual capacity of ALL our students. – Dr. Yvette Jackson

Therefore, cultural responsiveness as a framework has the potential to stand against any rigid prescriptions for effective teaching, and to systematically and comprehensively address the conceptualization, implementation and assessment of early AI education in diverse cultural contexts. Cultural responsiveness can be used as a pedagogical innovation to address the cultural gap between children's prior experience and the newly introduced AI ideas. It is also vital to approach holistic and interdisciplinary AI-focused STEM education via engaging, playful and hands-on learning experiences. To deepen children's learning, it is also suggested to draw upon societal, cultural, and equity issues related to AI. AI technologies are not without mistakes and prejudices. Culturally responsive AI education should allow meaningful classroom activities that link AI concepts and practices to children's background experiences, thus promoting their positive practices and perspectives in terms of AI technologies. As shown in Fig. 2, this kind of culturally responsive learning experiences can be achieved through the following procedures and structures (Wlodkowski & Ginsberg, 1995):

4.2.1. Establish inclusion

The AI activity should be accompanied with a learning atmosphere in which children feel welcomed and connected to each other. To achieve this, teachers can promote collaborative learning approaches, cooperative learning, peer learning, and sharing among children. Teachers should share the ownership of knowing with the learning community which is based on cooperative groups. They can start with a warm-up activity that can easily engage children.

4.2.2. Develop positive attitude

The AI activity needs to be linked to children's prior experience, knowledge, or skills. Children can be introduced to some cultural events or tools that they are familiar with before going deeper into sophisticated challenges or projects. For instance, ocean protection is closely related to Hong Kong children's experience due to the fact that Hong Kong is a coastal city (See the exemplar of *AI for Kids*). The approach of experiential learning should be emphasized in the AI activity to ensure pedagogical flexibility.

4.2.3. Enhance meaning

In the main activity, teachers should bring in learning experiences (e.g., design challenges) that require applying higher-order thinking skills in inquiry projects. The activity should be action-oriented, problem-posing, and relevant to some real-world issues, such as environmental protection (See the exemplar of *AI for Kids*). Children will be encouraged to raise critical questions and make decisions in the process. They will need to do investigation, experimental inquiry, artmaking, or design projects. For instance, children can learn about using AI technologies to clean the ocean and sort garbage (See the exemplar of *AI for Kids*).

4.2.4. Engender competence

In terms of evaluating children's progress and performance in AI education, the assessment should be related to their problem-solving scenarios and real contexts. Some of these assessment methods include

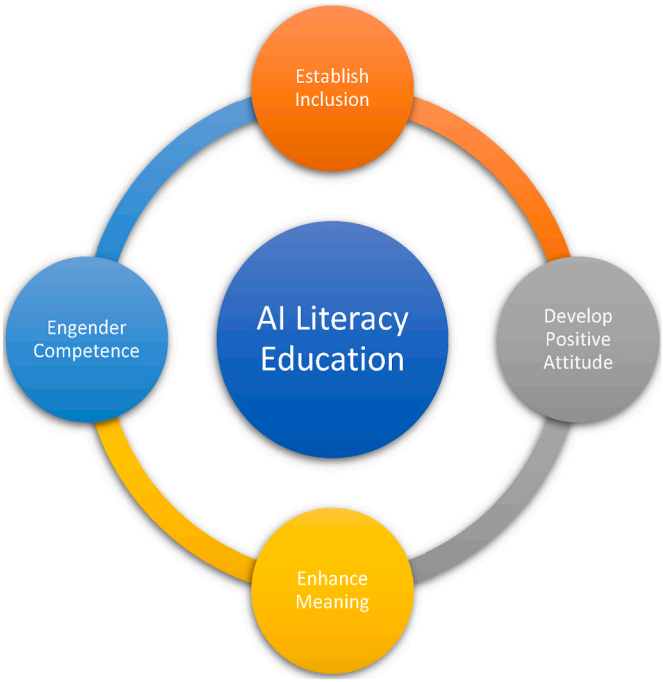

Fig. 2. The culturally responsive approach to AI education.

giving timely feedback, authentic assessment tasks, portfolios, artifacts, and self-assessment. Children can be given the opportunities to share their learning products or demonstrate their knowledge, skills, and inquiry process about AI.

5. "AI for kids" curriculum: an exemplar

The curriculum named "AI for Kids", was designed by the author's research team in Hong Kong. This curriculum aims to highlight the role of AI-powered technologies in human's daily life and to enable children to learn about AI using an embodied, project-based approach. The project focuses on environmental protection, especially ocean protection, which is culturally responsive to Hong Kong children's learning interests (See Fig. 3 for an overview of the curriculum used in a Hong Kong kindergarten). This is because Hong Kong is a coastal city with the longest coastline among global cities (CityLife, 2022). Hong Kong children have plenty of opportunities to visit popular coastal places such as islands and promenades. Some of them may be from seaside towns or communities. Therefore, the "AI for Kids" curriculum is designed with the incorporation of Hong Kong's local sociocultural contexts into inquiry projects for children to acquire the minimum understanding of AI which could enable them to know how AI affects the human society. This consideration ensures the cultural responsiveness of this AI literacy curriculum, thus enabling it to be inclusive and engaging for Hong Kong children.

5.1. Learning goals

There are three main goals for the "AI for Kids" curriculum. The AI literacy curriculum aims to enable young children to:

1. Recognize the basic principle of data processing of AI – the process of inferring results from information;
2. Understand and apply the basic principle and process of making judgments of AI - synthesizing information and identifying corresponding objects according to designated key elements; and
3. Understand the concept of prejudice, and recognize that AI also has prejudices and errors.

These learning goals are aligned with the key themes of AI literacy identified above, including the ideas that (1) AI technologies are created by human beings and can be trained with examples such as images, sound, and other types of information; (2) AI applications are trained and improved by human beings; and (3) AI applications have limitations and also make mistakes (Sakulkueakulsuk et al., 2018).

5.2. What and how to learn

In addition to the knowledge of children's understanding of AI, the learning activities in the "AI for Kids" curriculum also integrate knowledge of human life, music, language, STEAM (science, technology, engineering, art, mathematics), and literacy.

In terms of language, children listen to stories and learn about AI, picture books, and vocabulary in stories. In terms of humanistic life, teachers will provide children with common things in life, such as traffic lights, means of transportation, fruits, animals, and occupations, in order to enrich children's understanding of daily life; in terms of music, they listen to music and make specified actions or judge a certain means of transportation based on music. With regards to STEAM, they can learn about the thinking and training principles of AI through picture books and games, in conjunction with graphics cards and manual materials; through AI-power platforms such as *AI for Oceans* (https://code.org/oceans) and *Teachable Machine* (https://teachablemachine.withgoogle.com/), they can understand the process of AI inferring results based on information.

5.3. Learning evaluation

Teachers will need to observe the children's enthusiasm for learning AI, the process of understanding the basic principles of AI, and whether they can accumulate and apply the knowledge of each learning activity. Through the display and sharing of the results of young children, teachers can observe whether children can successfully complete the tasks of group activities and their ability to solve problems. The "AI for Kids" curriculum also provides a task asking children to draw AI based on their creativity. Teachers can evaluate the children's imagination of AI by observing how creative the children will complete the task.

Theme	• AI + Ocean Protection
Learning goals	1. Students can recognize the basic principle of data processing of AI – the process of inferring results from information; 2. Students can understand and apply the basic principle and process of making judgments of AI - synthesizing information and identifying corresponding objects according to designated key elements; 3. Student can understand the concept of prejudice, and recognize that AI also has prejudices and errors.
Materials	• iPads • AI-interfaced robot (*Popbo, Clearbot*) • Paper • Pictures • Recycled materials • Other related consumables   ***AI for Oceans***
Ocean-related activities	**Impacts of marine litter**: Personal story creation "Floating and sinking garbage"; role play of sleeping in plastic bottle waste; role play of being entangled with hanging garbage; designing tools to clean the oceans
AI-related activities	A total of six whole-class activities (two activities per week, each takes 30-35 minutes) • Activity #1: Introduction of *Clearbot* • Activity #2: iPad-based *AI for Oceans* • Activity #3: Guess what this is? (How AI recognizes objects) • Activity #4: Where is OO? (How AI processes information) • Activity #5: React with the triangle (AI has limitations) • Activity #6: Introduction of *Popbo*  ***ClearBot***  ***Popbo***

Fig. 3. Overview of the "AI for Kids" Curriculum
Note. The Chinese in the picture means: *React with the triangle!*.

6. Future directions for AI curriculum in early childhood

To introduce AI to young children, the "AI for Kids" curriculum has demonstrated the key considerations regarding why, what, and how to do AI education in early childhood. To further improve the curriculum design and implementation, further efforts can be done to achieve the following:

First, besides the project of environmental protection, more culturally responsive projects should be designed and implemented to enable children's exploration with AI technologies and to construct their early understanding of AI. Some of these themes that can be situated in real-world scenarios for young children include food (healthy versus unhealthy food), music (how robot can make music), and game (teach a robot to play a game). New project-based itionbnquiries with AI technologies will empower more children to acquire AI literacy in diverse contexts.

Second, besides *AI for Oceans* and *Teachable Machine*, new AI educational tools should be developed for young children and get incorporated into AI literacy curriculum to promote children's learning about AI. Notably, neither *AI for Oceans* nor *Teachable Machine* is primarily developed for children younger than six years. Therefore, there is an urgent need to develop AI educational tools with age appropriateness for the field of ECE, especially those that do not require prior programming experience and skills. The development of new AI educational tools for young children should lead seamlessly to the next for primary school students regarding the learning progression of AI literacy. This will further set a solid stage for lifelong AI literacy education, ranging from ECE to primary education, secondary education, and higher education coherently.

Third, the innovative pedagogical model concerning why, what, and how of AI education for young children discussed in this paper requires further testing in diverse ECE settings. AI curriculum in early childhood needs to be promoted and evaluated with an intervention study design, such as in-depth case study, quasi-experimental study, and randomized controlled trial. Teachers' perceptions of this pedagogical model can also be investigated to understand the usability of such an AI literacy curriculum for young children.

Fourth, the implementation of AI curriculum in early childhood is warranted to be analyzed and evaluated with the micro-analysis of children's learning engagement and outcomes. For instance, Chiu's (2008) technique of statistical discourse analysis offers a methodological approach to generating reliable evidence for understanding young children's learning with AI technologies. Since many AI technologies appropriate for young children have been incorporated into smart devices such as robots, it is essential to investigate the characteristics and consequences of child-robot interactions in diverse learning environments.

Last but not least, although the integration of AI education into school-based curricula might be a future pursuit, AI education in informal learning settings such as museums and libraries can also be focused on. Therefore, the AI curriculum in early childhood can also be deployed in these settings to enrich children's experiences. For instance, Sakulkueakulsuk et al. (2018) created a playful and hands-on AI exhibition in a public science museum to engage children in learning about AI.

7. Conclusion and implications

This article informs the broader field of how young children learn *about* and *with* digital technologies (Yang, 2021), with an emphasis on the equipment of AI literacy through effective pedagogical approaches and age-appropriate tools for introducing machine learning models. "AI for Kids" adds a new perspective to the conversation about early childhood curriculum and pedagogy. This article also deepens our understanding about "Why", "What", and "How" to do AI with children in the early years. The approach of culturally sensitive projects allows us to rethink the role of tangible AI-related learning experiences in ECE. Additionally, embodied instruction offers a pedagogical approach to promoting AI literacy in diverse ECE settings. The innovative pedagogical model comprised of key rationales for AI education in early childhood has practical implications for teaching and teacher education. This pedagogical model and its application in curriculum design and implementation will not only increase children's exposure to AI technology, but also enhance their thoughtful and nuanced reasoning about AI – an inclusive mindtool important for living in today's digital society. Promoting AI literacy for all (including young children) is a campaign of digital equity and will appeal to early childhood professionals and pedagogical leaders who want to understand and improve their own STEM/STEAM curricular practices through embedding AI.

Following previous research on AI integration in ECE (Su & Yang, 2022), the synthesis of knowledge regarding "Why", "What", and "How" to do with AI education for young children informs a new way to engage children in STEM and understanding the digital world. The pedagogical model proposed in this article provides the foundation for setting standards for AI education in the early years. It also provides the key principles for designing and implementing AI curriculum in early childhood, in both formal (e.g., preschools) and informal learning settings (e.g., home, museums, libraries). Preschool children will be empowered and enabled to acquire AI literacy in embodied learning experiences, which will prepare them for the intelligent future. As a developmentally and culturally appropriate pedagogical model (Li et al., 2021), this paper also informs how early childhood teachers can be trained to provide AI literacy education and more advanced STEM education. It thus fills the knowledge gap of supporting the emergence stage of AI literacy and completes the learning progression from early childhood to adulthood (Chen et al., 2020a, 2020b; Tang et al., 2021). Ultimately, implementing AI education would help equip children with early AI literacy, prepare them to face the challenges of the digital future and promote sustainabile development and social justice in ECE and the human society.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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