AI literacies for young children: A conceptual framework

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Artificial intelligence (AI) is rapidly transforming our society, with growing recognition among educators and researchers of the need to prepare K-12 students for an AI-driven future. Unfortunately, little attention has gone to AI in early childhood education (ECE; ages 5-8) (Su et al., 2023) despite its profound implications for young children's language development, cognition, sensory perception, and future learning trajectories (Ng et al., 2022; Su & Yang, 2022). Recent research shows that early introduction to AI is feasible, and suggests positive effects on children's AI knowledge and skills (e.g., Williams et al., 2019; Yang, 2022). However, these studies often focus exclusively on how children learn with and about AI, without fully considering the holistic goals and practices of ECE. The tension between holistic goals of ECE and new narrowly-framed learning goals is not unique to AI education. Our critical review of nearly 100 empirical studies on computational thinking (CT) in ECE from 2016 to 2022 (Wang & Proctor, 2022) found similar tension, resulting in inadequate consideration of diverse learners' needs and a superficial treatment of how CT might shape young children's holistic development. There is an urgent need to address and avoid such misunderstandings in ECE AI education.

To address this need, our NSF-funded project entitled *Exploring AI Literacies Framework for Young Children* developed an interdisciplinary framework for ECE AI learning by using the Delphi methodology, an iterative process of converging expert opinions on emerging topics. Guided by the Computational Literacies framework (Kafai & Proctor, 2022), we focus on these three fundamental questions across cognitive, situated, and critical framing of AI:

1. What: What are the most appropriate AI learning goals and content for young children?
2. Who: What developmental advantages/constraints and equity concerns must be considered for AI learning?
3. How: How can we introduce AI effectively and equitably?

Methods

This study used the Delphi methodology, an iterative process of seeking expert consensus through multiple rounds of interviews and feedback (Beiderbeck et al., 2021; Hsu & Sandford, 2007). The Delphi technique was well-suited to our goals, both because ECE AI education is still in its early stages, and because Delphi studies focus on "what could/should be" rather than solely on "what

is" (Miller, 2006), allowing us to concentrate on building a durable paradigm for integrating rapidly-evolving AI technologies into ECE.

We assembled a panel of 30 experts for our Delphi study across the fields of AI, Child Development and Early Education, K12 Computer Science Education, and Child-Computer Interaction. We initially compiled an initial list of well-known experts in these fields, and then sought nominations from leaders of professional organizations, journal editors, and influential practitioners in education and industry, with selection criteria based on qualifications and expertise in their respective domains (Devaney & Henchion, 2018). We requested that this initial group complete a demographic survey and then consulted with a group of colleagues to identify missing voices and underrepresented perspectives within our panel of experts. Then, without using any kind of quota, we proactively recruited the remaining panelists to address the gaps we identified. The study's final panel of experts is racially and linguistically diverse, with 60% being non-white and 57% speaking at least one language other than English. The panel's fields of expertise and sector are shown in Figure 1.

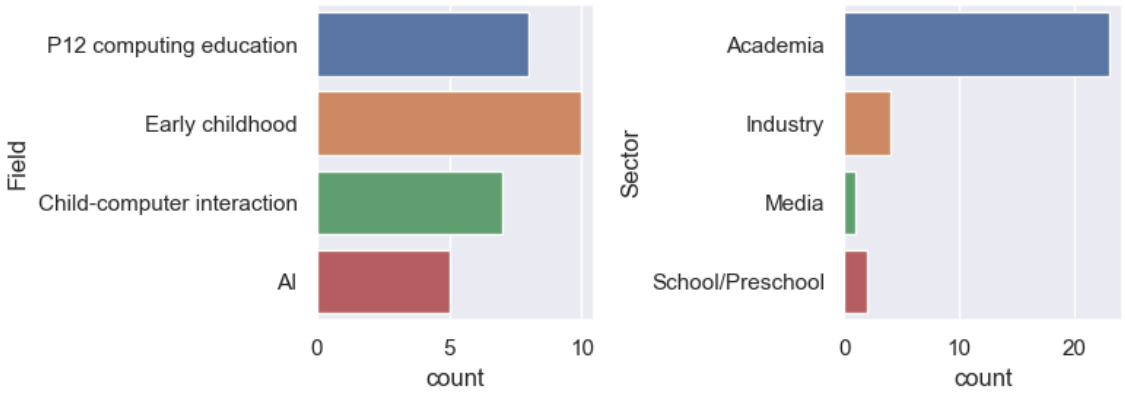

Figure 1: *Expert demographics*

The expert panel participated in three iterative rounds of discussion and feedback. The first two rounds were 90-minute small-group interviews over Zoom; the third round solicited written feedback on the draft framework. (Results of the third round of feedback are forthcoming.)

In Round 1 (winter 2024), we conducted six semi-structured interviews focused on the project's three main research questions with experts roughly grouped within their fields of expertise. These interviews took place over via Zoom and lasted about 90 minutes each. After manually reviewing and correcting the Zoom-generated transcripts, the research team (PI Wang, Co-PI Proctor, and two graduate research assistants) first conducted open coding individually. Then, assisted by qualitative data analysis software (Proctor, 2024), we iteratively organized the codes and converged on the main themes. We used the final codebook to gather relevant excerpts from the transcripts and then produced a first draft of the framework which described the themes and summarized expert opinions with key quotations.

In Round 2 (spring 2024) we sent the draft framework to experts and asked them to read and annotate, focusing on where they agreed or disagreed with our summary, what was missing, and their thoughts on the framework's structure. We conducted a second round of 90-minute interviews over Zoom, this time grouping experts across disciplines so that we could consider areas of disagreement from multiple perspectives. These discussions were again semi-structured:

they were organized around the draft framework with specific questions prepared around several particularly contentious issues. We again reviewed and corrected the Zoom-generated transcripts (as well as expert annotations of the draft framework), and then coded them according to the structure of the draft framework. Then PI Wang and Co-PI Proctor revised the draft framework by synthesizing the discussion around each section of the draft framework, and then reorganizing the framework's structure. The result was a second draft of the framework.

Finally, in Round 3, the second draft of the framework was sent to each expert, along with a form asking the expert for their level of agreement with each section and feedback on the section. The feedback from this form allowed us to make final revisions to the framework, and to report on experts' levels of agreement with each section showing where consensus exists and where disagreements remain. We have not yet completed analysis of Round 3, so the framework in this report reflects the second draft.

Executive Summary

Scope, Audiences, and Contexts

This project's focus was on young children learning about AI rather than integrating AI into education. The intended audiences include education researchers across various domains, AI tool designers, and curriculum planners. We recognize the central and agentic role of teachers and parents in young children's educational experiences, but they are not a primary intended audience of this report. Instead, we hope this the framework presented below is used in the creation of accessible materials designed for teachers and parents.

Although we sought consensus where it existed among experts, the discourse highlighted the presence of multiple tensions, such as the rapidly evolving nature of AI clashing with the desire to establish a foundational knowledge set for K-12 learning. There was also a tension between the holistic development of children in early childhood education and viewing this stage merely as a precursor for future achievement. Additionally, there was a debate on whether seeking a unified definition or framework was productive, given the scarcity of foundational research in prevalent areas.

Defining AI Literacy for Young Children

The goals of AI literacy for young children should ensure that children **not only become adept at using AI but also develop a balanced understanding of its capabilities, limitations, and ethical implications**. Here are some critical aspects to consider when defining AI literacy for this age group:

1. Understanding AI Concepts: At a fundamental level, AI literacy for young children should include basic knowledge of what AI is and isn't. This includes understanding that AI involves computers and programs that can make decisions or perform tasks that typically require human intelligence, like recognizing speech and faces, solving problems, or learning from data.
2. Interaction Skills: Young children should learn how to interact safely and effectively with AI technologies. This includes using voice assistants, interactive games, or AI-driven educational tools. It's crucial that they learn the mechanics of these interactions as well as their boundaries.

3. Ethical Awareness: Even at a young age, children can grasp the concept of fairness and the basics of right and wrong. AI literacy should therefore include discussions questions such as What does it mean to be human? What kind of relationship should we foster between humans and technology? What should the rules be for making and using AI? What should our future with AI look like? It should address key ethical issues such as privacy, explainability, bias, and human-machine interactions, along with ethics processes like perspective-taking and thought experimentation.
4. Critical Thinking: Children should be encouraged to think critically about AI, questioning how and why it might make certain decisions. This can be introduced through stories or scenarios in which AI behaves in unexpected ways, prompting discussions about how the AI might be thinking and why it might make mistakes.
5. Creative Use of AI: Encouraging children to think of AI as a tool for creating and solving problems can help them see AI as a positive and useful technology. This could include using AI-powered tools for drawing, making music, or solving puzzles.
6. Safety and Privacy: Basic principles of digital citizenship, including personal safety and privacy in digital spaces, are crucial. Children should be taught what information should not be shared with AI and the importance of maintaining privacy online.
7. Awareness of AI's Limitations and Biases: It's important for children to understand that AI is created by humans and can inherit human biases. Discussing AI's limitations in a simple way can help them understand why an AI might not always understand them or might make mistakes.

Defining AI

In the context of our AI literacy framing, we define **Artificial Intelligence (AI)** as the capability of a machine to imitate intelligent human behavior. AI enables computers and other machines to perform tasks such as learning from examples and experiences, recognizing patterns, making decisions, and solving problems. Common examples of AI technologies in young children's lives include speech recognition (like talking to a virtual assistant Alexa, Siri), image recognition (such as identifying objects or faces in a crowd, e.g., scanner in grocery store), decision-making processes used in personalized online experiences (e.g., YouTube video recommendation systems), and educational tools that personalized learning and tutoring (e.g., Khanmigo).

The question of whether we should attempt to define AI (in the context of early childhood education) elicited diverse opinions among experts. Some argued that over-simplifying AI into a neat definition could lead to confusion, drawing parallels to earlier debates around screen time (which sometimes unhelpfully lumped all interactions with screens into the same category). They noted that AI is multifaceted, prompting reflection on which aspects should be emphasized educationally and which core elements would stay constant amid technological advancements. A practitioner mentioned the comfort in introducing concepts that can be clearly defined, suggesting a potential benefit to establishing boundaries for AI in learning contexts. However, there was also a sentiment against "thingifying" AI excessively, proposing that not centering AI as a discrete entity might be advantageous. The discussion included the idea of teaching AI concepts during early childhood, though clearly distinguishing it from merely transplanting learning appropriate for older ages. While evidence of necessity for early childhood AI education was questioned, some consensus emerged that certain skills have foundational importance starting at a young age. Our definition aims to encapsulate the essence of AI without delving into the technical complexities, making it accessible for educational purposes and everyday understanding, especially in the context of ECE.

1. AI in ECE discourse

1.1 Framing the discussion in context

The experts often situated their views and discussions in these three main contexts: sociotechnical, sociocultural, and educational.

1.1.1 Sociotechnical context: AI In society

In the discussion of AI's role within society, particularly in relation to young children, experts stressed the necessity of critically evaluating the broader macrosystem—comprising policy, capital, funding, and socioeconomic frameworks—where AI operates. It was widely recognized that AI, described as a foundational technology, is integrally woven into the fabric of modern life, thus exerting significant influence on both society and education. Experts noted that AI has become pervasive in domestic environments, educational settings, libraries, and public spaces, making the isolation of children from these technologies seemingly impossible. From as early as ages 2-3, children encounter and interact with AI tools, displaying curiosity and interest. Discussions highlighted the importance of considering how children not only learn about AI but also play and learn with it. Additionally, AI's non-monolithic nature was underscored, with various tools such as Alexa, Siri, ChatGPT, robots, Roomba, and social media algorithms being frequently mentioned. Some experts suggested distinguishing between AI agents, which are more comprehensible to children, and underlying algorithms, used in services like Google search and Facebook. Overall, the dialogue emphasized a nuanced understanding of AI's diverse roles and impacts on children's developmental experiences in contemporary society.

1.1.2 Sociocultural context

Experts have expressed concerns that AI could exacerbate existing inequities in education by widening the digital divide, affecting both access and quality of learning experiences along racial, economic, and geographic lines. Gender was notably not highlighted as a major concern in early childhood education (ECE) regarding AI implementation. Additionally, experts point out that differences in resources, development, and policy decisions across countries will lead to varied experiences with AI for children worldwide. While China is noted for its rapid integration of AI in education, it does not allow AI content for early childhood education. Moreover, when discussing neurodivergent learners, experts noted that digital technologies, including AI, have greatly enhanced educational experiences by fostering more relaxed and enjoyable social interactions online. They caution against creating a "harmful narrative" that solely values traditional in-person play and socialization. To address educational inequity, experts suggest the potential roles of mass media programming, such as PBS Kids and Sesame Street, and libraries as alternative avenues of support. Furthermore, experts emphasize the critical role of engaging families and caregivers in making "locally relevant" educational decisions, noting that perceptions of AI in schools can vary significantly between low socio-economic status communities, which may see AI as a tool for enhancing economic mobility, and more privileged families, who may seek to curate specific learning experiences, ranging from reduced screen time to high-quality AI extracurricular activities.

1.1.3 Educational context

Experts on the educational context of AI usage in schools expressed a complex range of views regarding its implementation. They acknowledged the potential of AI to alleviate teachers

from mundane administrative tasks, thus allowing more meaningful engagement with students. However, some cautioned against limiting AI's role to enhancements like tutoring systems or surveillance, urging instead for its use in fostering "critically imagining" skills. There were significant concerns about the undemocratic nature of how AI tools are selected, often excluding teachers and parents from decision-making processes, which raises questions of accountability and transparency. Furthermore, experts stressed the importance of maintaining the inherent "messiness" in early childhood education (ECE), warning against AI-driven standardization that could impede personalized learning. They highlighted the need for AI to support rather than distract from ECE priorities such as imaginative play, creativity, and the development of foundational social and emotional skills.

1.2 Attitudes Toward AI Education in ECE

Experts expressed a great deal of ambivalence towards AI in ECE: caution, skepticism, as well as optimism. Sometimes the same experts shared both optimism and skepticism. They also disagreed on the urgency for action as well as how/what to go about it.

1.2.1 Skepticism

The discourse among experts regarding skepticism toward AI in education reveals a spectrum of views. While there is a collective endorsement for introducing AI literacy to young children, emphasizing the importance of adapting them to study responsibly with AI, significant skepticism persists, particularly concerning its role in early childhood education (ECE). Critics argue that ECE should emphasize "play" and "socioemotional learning," drawing inspiration from proven models like Reggio Emilia and Montessori. Notably, computing education experts warn against replicating the pitfalls of existing K-12 programs, which prioritize superficial content over creativity and interdisciplinary learning. Meanwhile, some child development experts argue that young children are capable of understanding abstract AI concepts, challenging the belief held by EC practice and HCI researchers that AI is too abstract for them. Additionally, concerns were raised about the academic skepticism potentially being out of touch with certain communities, such as those of low-income families, who might view early AI education as vital preparation for future challenges. Moreover, there is a critique that reliance on AI tools like ChatGPT might inadvertently sideline the development of foundational skills, such as reading and writing.

1.2.2 Caution

In considering the integration of AI in education, particularly for young children, a majority of experts emphasize the necessity of "caution and care." They identify several critical issues that warrant attention, including children's rights, the need for informed consent, ensuring safety and privacy, and addressing bias. Concerns about AI as a "black box" and data security are highlighted, along with the risk of worsening the digital divide. The experts strongly advocate for robust regulation and legislation to safeguard these areas. Additionally, they caution against the potential adverse effects of AI on children's learning and development, citing negative impacts on social relationships, mental health, and social-emotional learning, as well as the risk of digital addiction and misconceptions of AI as sentient beings. The experts argue that AI, without careful oversight, could be likened to a "huge unregulated natural experiment," influencing not only individual cognitive development but also broader societal constructs.

1.2.3 Optimism

In discussing the topic of "Optimism about AI in education," experts expressed varying views, with some conveying cautious optimism and affirming that "kids are okay" despite the integration of AI into learning environments. A number of experts suggested that prevailing skepticism may stem from a lack of understanding of how young children and their families perceive and experience AI technologies. One expert referenced existing research on game playing to highlight the potential positive impacts of AI on education, noting that such activities can enhance skills like making fast decisions under pressure, which could be particularly beneficial for certain career paths. This underscores the complex landscape of opinions surrounding AI's role in education, particularly regarding its effects on children.

1.2.4 Urgency For Action

Experts are divided on the urgency of integrating AI education into early childhood curricula, with some asserting it is "our responsibility" to provide young children with a basic understanding and appropriate attitudes toward AI. These proponents argue for incorporating AI education in public schools as a means to mitigate inequities in access and resources and caution against relinquishing control to entities with workforce-oriented or corporate agendas. However, they recognize the complexity in defining a baseline understanding of AI due to its rapidly evolving nature—a "moving target." Conversely, some early childhood practice experts advocate for adhering to consensus content, which is met with resistance from child development experts who believe young children's capacity to grasp abstract concepts is often underestimated. This debate underscores the varied perspectives on how to effectively implement AI education for young learners.

1.3 Conceptual Structures

Experts referenced a range of metaphors and existing frameworks in their discussion about AI in ECE.

1.3.1 Metaphors

Experts drew on a rich array of metaphors in discussions. One group of metaphors was used to illustrate the pervasive role of AI in children's current and future lives, comparing it to utilities like electricity and plumbing. This suggests AI will become a fundamental part of daily life, yet its ubiquity does not necessarily warrant prioritizing its integration into early childhood education. AI is also likened to personal devices such as smartphones and tablets, indicating the necessity of establishing social norms around AI usage and promoting conversations with young children about its role. Additionally, AI is compared to traditional media, implying that the initial novelty will wear off as society adapts to its presence. These metaphors highlight the diverse perspectives on navigating AI's integration into educational contexts.

Experts considered AI as a new domain of learning, akin to a new language that allows for different modes of understanding and expression. This invites inquiries about what children should learn at different ages, leading to debates on whether AI should be a separate subject or integrated into existing curricula. Comparisons are made to teaching table manners or discussing sensitive topics, suggesting that AI education should be optional and contextually appropriate. The analogy to germs underscores children's ability to grasp complex concepts, implying they

can also understand AI's fundamentals. This discourse reveals AI's potential and the nuanced considerations required for its educational role.

Other metaphors explored whether AI should be viewed as a tool or a field of learning. Some argue that AI should be seen like a dictionary or encyclopedia, emphasizing the need for children to learn how to use AI effectively, while others liken it to books as cultural tools. The comparison to Microsoft tools highlights the significance of AI proficiency for future workforces. Another perspective portrays AI as a creative partner that can enhance children's imaginative capacities, illustrating the varying thoughts on whether functional proficiency should take precedence over in-depth study of AI itself.

Other metaphors were used to suggest that children should cultivate particular relationships with AI, with one analogy depicting AI as "companion pets," fostering nurturing interactions, and another likening it to a "puppet," emphasizing the reassurance needed in AI's presence. Experts stress the importance of distinguishing between AI and human interactions, guiding healthier engagement and critical thinking about technologies.

A final group of metaphors were used to express safety concerns regarding AI. One analogy likens AI to slot machines, indicating the digital addiction risk posed by AI algorithms designed to capture attention, suggesting regulatory measures similar to those for gambling. Alternatively, AI is compared to scissors—potentially harmful if misused but valuable when used correctly—advocating for teaching safe and effective utilization rather than imposing restrictions. These diverse viewpoints emphasize the need for balanced approaches to AI in educational settings.

1.3.2 Frameworks

Experts cited a diverse array of frameworks for contemplating and designing AI literacies in education. The Developmentally Appropriate Practice (DAP) emphasized the importance of adapting learning to children's developmental levels and cultural backgrounds, while the 100 languages of Reggio Emilia advocated for multifaceted expression through various symbolic representations. AI4K12.org's 5 Big Ideas framework (2020) structured AI around perception, representation and reasoning, natural interaction, machine learning, and ethics and social impacts. Sara Vogel and her colleagues promoted teaching about, with, through, and against technology to develop nuanced AI literacies. Luo, He, Gao, and Li's (2024) framework underscored access, affordability, accountability, sustainability, and social justice in early childhood education. Papert's (1980) constructionism and Piaget's constructivism focused on learning through constructing and interacting with the environment, respectively. The ALA media literacy framework and the NAEYC early literacy framework provided guidance on responsible media use and age-appropriate AI content mapping. Experts also highlighted the importance of participatory design in engaging stakeholders and developed frameworks such as Ito and colleagues' connected learning (2013), equity-oriented and socially connected, and Druga, Yip, Preston, and Dillon's 's 4As (2023) (ask, adapt, author, analyze) for technology literacy and justice. Kafai & Proctor's computational literacies framework (2022) was repeatedly cited by experts during discussions. Almost all experts agreed that Kafai and Proctor's framework was a suitable conceptual framework for the project.

1.4 Stakeholders

1.4.1 Who Benefits from AI Ed

One expert warned against the false promise of technology for a better and more equal society. Daniel Greene's book *The Promise of Access*, which explores "how the problem of poverty is

transformed into a problem of technology" (p. 5) and critiques the neoliberal policy emphasis on providing STEM education for social mobility instead of investing equitably in social services and dismantling sources of oppression. Another expert argued that "more computing is not gonna lead to a better world." However, others pointed out what if communities of high needs explicitly request skills training. Thus, it is important to establish "locally relevant" AI education with stakeholders in considering and designing AI experiences and learning for young children.

1.4.2 Children

As the key stakeholder, experts called attention to understand what they bring to table when designing both AI tools and AI learning experiences in ECE. The use of a participatory design framework was suggested to center their experience.

1.4.3 Family

The examination of family roles as stakeholders in AI education revealed that young children's initial interactions with AI tools like Alexa, Siri, or Roomba are likely to take place at home, paralleling how they engage with social media. However, the novelty of AI means many parents lack sufficient understanding or knowledge to guide such engagements. Experts stressed the necessity of supporting parents and caregivers in initiating conversations about AI and engaging in "joint media engagement" with their children. They highlighted the increased severity of these knowledge gaps in marginalized communities, thus emphasizing the importance of equipping parents with AI knowledge to bridge this digital divide. Propositions included expanding resources similar to those provided by Common Sense Media and empowering parents to partake in AI tool selection in educational settings. Recognizing parents' "folk knowledge" and respecting diverse views, especially concerning privacy and security issues sensitive to Black and brown communities, were seen as crucial steps. It was also acknowledged that while families should participate actively in designing AI learning experiences, not all parental involvement is beneficial due to varying parenting styles, which can impact children's learning and development detrimentally. Therefore, collaboration between educators and families is essential to ensure productive AI introductions for children.

1.4.4 Teachers and Schools

Experts noted that teachers are pivotal in helping students navigate AI, particularly since schools may be the only venue where children from certain communities can access AI tools. However, they acknowledged that teachers, akin to parents and caregivers, often possess limited knowledge or understanding of AI. As such, it was deemed essential to provide professional development for teachers to enhance their capability to both teach with AI and educate students about AI. Furthermore, equipping teachers, IT professionals, and administrators with AI knowledge was crucial to empower them in influencing school decisions regarding AI systems, rather than relinquishing control to commercial vendors. The experts also highlighted that utilizing AI tools to handle procedural or tedious tasks, such as paperwork and student progress tracking, could potentially free up teachers' time, allowing them to engage students in more profound and personalized ways. Vogel's framework was recognized as beneficial for teachers in contemplating how to teach about, with, through, and against technology.

1.4.5 Communities

Experts emphasized the pivotal role of communities as stakeholders in AI education, advocating for the design of AI learning experiences that resonate with both the form and content specific to communities. They stressed the importance of "providing something to the community on the community's terms," suggesting that engaging communities to develop "locally grounded community agreements" is essential in deciding whether and how AI should be introduced to young children. Furthermore, experts highlighted the need to encourage children to center their learning around their community by participating in projects that connect AI learning with their community's needs, thereby making it meaningful. Additionally, they cautioned against the potential of AI tools to isolate rather than expand community connections, drawing parallels to the adverse effects observed with social media, which often fractures social ties by reinforcing narrow beliefs within particular communities.

1.5 Research and Regulation Needs

Throughout the conversation, expert panelists identified many research and regulation needs. Below we list a few most pressing ones.

1.5.1 Research Priorities

Experts have identified several urgent research priorities regarding AI education for young children, underlining the extensive knowledge gaps that exist. There is a pressing need to understand young children's perceptions of AI and their experiences with AI tools, especially given the rapid evolution of these tools. Experts suggest that funding for longitudinal projects is crucial to explore the long-term effects of AI technology on children's learning and development, framing it as a "large, unregulated natural experiment on our brains." Studying co-design contexts and supporting local communities is considered essential for understanding emerging AI applications. Furthermore, comprehending families' "folk knowledge" and perceptions about AI, including which forms they are comfortable with, like Alexa versus large language models (LLMs), is critical. Understanding teachers' attitudes and the challenges they face in schools is equally important. Research is also needed to define which AI tools, features, characteristics, or concepts are developmentally appropriate for young children, along with assessments for evaluating AI tools and children's learning about AI.

1.5.2 Regulation Needs

The experts agreed that children are too young to make informed decisions regarding AI tools, emphasizing the urgent need for regulatory measures. They cited critical issues such as data privacy, biases, and security that necessitate regulation. The international landscape illustrated a diverse approach, with China providing less restriction compared to the EU's more stringent regulations, while the US was considering broader regulation strategies. Such varied national policies could impact children's access to AI differently across countries. Regulation, as noted with Scotland's revised education age, could safeguard children's social interactions and prevent premature academic pressures. In capitalist societies, reliance on the tech industry to self-regulate is insufficient; meaningful regulation is necessary to provide the needed guardrails. Parents and educators, often lacking AI knowledge, struggle, indicating a need for regulatory support on the supply side. Moreover, to combat digital addiction, regulations should promote AI tools that enhance self-regulation and self-directed learning in children. The complexity of defining AI presents a significant regulatory challenge; however, a proposed model similar to clinical trials

might offer a phased and controlled approach. Lessons could be drawn from existing legislative efforts in regulating social media and frameworks like HIPAA. The discussion also touched on the potential for an AI education certification to aid in these efforts.

1.6 Meta-discourse

Throughout these panel sessions, there was a parallel discussion about these sessions themselves among the experts as well as among the research team. They might not be directly related to the AI literacies for young children, but it is worthwhile to highlight a few of them to show how the experts and the research team grapple with and make sense of these issues. The experts, drawn from varied fields, were expected to echo similar sentiments within their sectors, yet the process uncovered a surprising diversity of opinions that spurred dynamic debates. Academics predominantly relied on their academic research; however, many also drew from personal parenting experiences to inform their views, highlighting their awareness of socio-economic and cultural privileges that might not resonate with all community experiences. While no significant differences emerged between academic and industry perspectives, there was notable resistance to the notion of business or technical power dictating AI's educational future. Furthermore, there was a strong emphasis on aligning AI education discussions with real-world issues, particularly foregrounding concerns around equity.

2. What: AI Learning Goals and Contents

In thinking about what young children should learn about AI, we adopt Kafai & Proctor's (2021) computational literacies framework, which was originally used to distinguish between three framings of computational thinking (CT): cognitive, situated, and critical. These framings differ in terms of scale and epistemology: cognitive CT is focused on individual skills and knowledge; situated CT is focused on social practice within groups; critical CT is focused on making knowledge useful and powerful within the broader scope of learners' lives. We found that the computational literacies framework also worked well to distinguish ECE AI learning goals and contents.

2.1 Cognitive learning

Cognitive learning goals can be understood as disciplinary knowledge and skills–"content" which could be learned and tested. Although there were exceptions, most panelists put less emphasis on cognitive learning goals for early childhood education, with some arguing directly that "we do not need an AI curriculum" or drawing analogies to K12 computer science (CS) education, with the suggestion that K12 CS has become overly focused on learning disciplinary content.

2.1.1 Defining AI

The panelists discussed the challenge of defining AI, noting that AI is a rapidly evolving technology which complicates establishing a clear, stable definition. They emphasized that definitions should distinguish between AI and machine learning, suggesting that AI should be understood in terms of the social experiences it enables, which is more relevant for children, while machine learning should refer to the implementation aspect. The nature of AI, unlike straightforward definitions of concepts like multiplication, requires a more flexible understanding that adapts to different problems and questions being addressed. Some experts questioned the value of a non-technical definition, suggesting that varying definitions might be beneficial for distinct fields and contexts. The conversation also highlighted the importance of defining AI based on how it is experienced

and controlled by people, tailored to the various guises in which individuals, especially children, encounter it. This approach acknowledges that AI is intricately woven into various technologies, often implicating different perceptions across age groups. The risk that differing definitions could lead to a lack of shared understanding was also recognized, emphasizing the need for nuanced distinctions, much like past debates over screen time considerations.

2.1.2 How AI Works

The panelists expressed diverse opinions on whether it was important for young children to understand how AI works. Some argued for introducing age-appropriate concepts related to AI algorithms, training models, and the significance of training data in AI inference, referencing the AI4K12 framework and stressing fundamental computer science principles like abstraction and decomposition. However, the discussion revealed disagreements; some experts contended that a social definition of AI makes the technical aspects less relevant to children's education, as children's understanding could be limited to unverifiable stories. Additionally, this lack of clarity in AI's definition was noted as a barrier to enhancing teacher capacity. Advocates of a computational thinking approach suggested focusing on machine learning as a problem-solving method driven by examples rather than rule-based programming. The fundamental difference between AI and traditional computer science was emphasized: AI involves computers learning from examples, making data comprehension crucial for students. Nonetheless, it was noted that understanding how AI operates might not be essential for using or benefiting from it, akin to the way people use aspirin without knowing its precise workings.

2.1.3 Interacting With AI Systems

Panelists from most groups argued that young children should learn how to work with AI systems, for example training models, using models for inference or classification, and analyzing model predictions for errors. However, there was skepticism regarding the assumption that children would engage in "magical thinking" about AI. As one expert questioned, "What is the evidence that children engage in magical thinking and apply such thinking to AI?" Another pointed out that this misconception might pertain more to adults whose understanding of digital technology has been disrupted, rather than children. The importance of distinguishing AI as a separate entity in digital experiences was deemed questionable; panelists debated whether children should be explicitly taught AI interaction techniques or could learn independently. Some skeptical voices even doubted the necessity of teaching AI-related skills such as prompt engineering. Overall, while it was acknowledged that equipping children to avoid AI misconceptions is important, there is still a lack of empirical understanding of what these misconceptions might entail.

2.2 Situated learning

The panel of experts explored the notion of situated AI learning, emphasizing its foundation on cognitive processes while highlighting that a student's identity and the significance of their actions are forged through continuous interaction within a community of practice. Situated learning aims to foster identity and participation, though there was some disagreement among experts about the relative importance of cognitive versus situated learning approaches. This division was evident in discussions about whether it is more critical for young children to understand the technologies behind AI user interfaces or to become adept users of these interfaces within their social contexts. Additionally, the experts suggested that AI should be approached in terms of media literacy and cautioned against framing AI education solely as content. Drafting AI learning frameworks that

focus on participation within social environments and emphasize media literacy over content is vital for effectively integrating AI into educational contexts.

2.2.1 Recognize AI

The panelists viewed the issue of children recognizing AI technologies as multifaceted. While many agreed it was crucial for young children to not only recognize AI interfaces but also understand the underlying technologies, there was debate on the necessity of this goal. Some suggested that in an era where "AI will be in everything," recognizing AI might be a transient learning objective. One panelist suggested that the focus should be on understanding how AI affects user experience, such as data collection and decision-making processes. Concerns were raised about children's vulnerability to misconceptions, as they often engage in imaginative play and might attribute human qualities to AI. However, others argued that children naturally engage in role-play without confusion. Instead of unnecessary learning goals, some panelists advocated for policies protecting against deceptive technologies, cautioning that anthropomorphizing AI could obscure vital realities of digital experiences dominated by data systems. This reflects a broader argument for integrating cognitive, situated, and critical understanding of AI. An interesting research opportunity was noted on children using their developing theory of mind to reason about AI interfaces.

2.2.2 Appropriate Social Relationships With AI

Many panelists acknowledged that AI, particularly embodied or agentive AI systems, is increasingly becoming part of young children's social worlds, necessitating socioemotional learning goals that include understanding appropriate relationships with AI. Most emphasized that AI, while requiring polite interaction, should not be viewed as a friend, reflecting concerns about the superficial replacement of genuine social interactions. Distinctions in the quality of media engagements were noted, with the potential variety in social engagement through synthetic means acknowledged. A few experts cautioned against prescriptive social norms due to their constantly evolving nature and underscored the significant impact our relationships with technology have on self-perception and developmental paradigms. There was a strong sentiment against treating AI as people, with one expert noting that "to view AI as a friend requires trust and it is perhaps dangerous to view it as more than a tool," likening AI to non-social tools like cars. Yet, some openness exists to considering AI's person-like status as part of a broader relational approach. Furthermore, digitally-mediated interactions, even partly synthetic ones, were recognized for their value, especially for children with special needs. Lastly, the discussion highlighted the substantial choice society faces in deciding whether AI interfaces should be treated as people, noting moral/ontological implications.

2.2.3 AI as a Creative Partner

Experts agreed that creating with AI was identified as a situated learning goal, rooted in constructionist values, emphasizing the creation of personally meaningful projects and interest development. While some experts highlighted AI as a powerful tool, others perceived it as a cultural tool, akin to early childhood psychological constructs. AI was seen as a partner in creativity, acting as a complementary collaborator that compensates for the child's unlearned skills. However, there was debate regarding the necessity of understanding the functionality behind AI tools, as typically one does not need in-depth knowledge to use any tool skillfully. The design of kid-friendly AI could allow children to build and reuse new AI tools, aligning with computer

science principles where one creates their own tools. Additionally, some panelists debated the importance of disclosing AI use, voicing concerns more relevant to academic honesty than early childhood education. Ultimately, trust was considered essential for using AI as a tool, suggesting that policy, rather than user education, may effectively foster this trust.

2.3 Critical learning

A critical perspective zooms out even further, considering individuals and communities of practice within the context of broader cultural discourses and power structures. Critical AI learning would aim to help learners understand how AI is changing our world. Critical learning is particularly urgent for students marginalized by race, gender, and other social categories: culturally-sustaining (Paris, 2012) pedagogy argues that it is essential for these students to understand and resist oppressive social structures.

2.3.1 Questioning

The panelists emphasized the importance of fostering children's natural curiosity, advocating that they be encouraged and empowered to ask questions about AI and challenge its operations. This was deemed crucial, as AI is predicted to become as pervasive and influential as social media, potentially using dark patterns to shape behavior. However, there was debate about whether it is realistic or necessary for children to understand AI's underlying systems, given past difficulties in teaching them the workings of the Internet and digital technologies. Some questioned why understanding AI's systems was more critical than comprehending other complex systems, like internal combustion engines. It was suggested that focusing on critical thinking should not be exclusive to marginalized children, nor should technical skills be reserved solely for privileged ones. On a more optimistic note, some experts suggested AI could enhance learning in various areas, with potential to provide children with more informative answers to questions about subjects such as biology or climate change than a busy or uninformed parent might.

2.3.2 Agency

In discussions on supporting children's agency in interacting with AI, a K12 computing education panel emphasized the importance of children understanding and asserting their rights, highlighting active consent as a critical aspect, such as opting out of being photographed or recorded. However, some experts suggested a focus on developing social norms around AI, likening it to communal decisions about mundane activities, such as whether to keep the lights on. Additionally, the concept of transgressive play was highlighted as an important early childhood education practice. This prompted a broader conversation on the stigmatization of hacking as a creative act, where it was argued that school IT departments may hinder students and teachers by enforcing overly serious attitudes towards interaction with technology and AI. The experts contended that encouraging exploration and a degree of playfulness can better support children's agency and understanding of AI systems.

2.3.2 Shaping AI as a Social Category

Some panelists felt strongly that children should be considered and involved in the ongoing development of AI as a social category. Experts pointed out the ambiguity surrounding AI's social integration, such as whether AI agents should disclose their identity, identifying scenarios where AI might be inappropriate, and delineating the social responsibilities expected of AI. It

was argued that children engaging in "critical imaging" could shape the societal futures we envision. Furthermore, it was suggested that AI might significantly influence children's moral and ontological categorizations. Nevertheless, while the panel acknowledged the value of having some form of definition for AI's social role, they cautioned against relying solely on a technical definition of what constitutes AI.

2.3.3 Bias and Representation

Panelists from various disciplines highlighted the importance of integrating awareness of algorithmic bias into children's education, emphasizing how AI can reproduce existing societal discrimination or oppression rather than being inherently inclusive. They compared this to other media literacy pedagogies, such as questioning information without taking it at face value, drawing parallels between AI bias and the biases historically embedded in textbooks. The experts discussed the scope of bias and representation within broader media literacy, asserting this issue is not unique to AI but reflects ongoing challenges. A critical approach was deemed vital, with suggestions that caretakers and educators guide children to probe AI with questions such as making it identify itself. The panelists emphasized connections between bias and the data AI systems consume, underlining that AI merely echoes patterns found in its inputs rather than conveying objective truth, acting as a "universal talker."

2.3.4 Impacts of AI

In discussing the impacts of AI, experts from various fields emphasized the importance of educating young children about AI's influence on multiple levels, such as societal change and human relationships. They noted the predominance of discussions about the implications of AI over its mechanics, highlighting an incident where a child questioned the intentions behind the use of a ring doorbell camera rather than its functioning. The dialogue revealed a divide among panelists, with a minority expressing optimism regarding AI's capability to solve societal issues and improve community well-being. Meanwhile, there's acknowledgment that AI's societal impact is potentially more significant than previous technological advancements like the internal combustion engine due to its ability to shape intellectual processes and influence societal interactions fundamentally. Additionally, while the notion that AI's potential biases stem solely from its creators' lack of diversity was challenged, there was consensus that AI should be recognized as human-made, offering scope for alternate designs. These insights underline the critical evaluation of AI's societal role beyond its technical workings.

2.4 Visions

Following Vogel, Santo, and Ching's (2017) CS Visions Framework, visions articulate beliefs about the deeper purpose of education. At least within US education, there is a long history of arguing about the purpose of public education which reflects beliefs about human nature, the role of the state in peoples' lives, and the kind of society we ought to have. A community's embrace of a vision could help justify particular learning goals.

2.4.1 College and Career Preparation

While some experts emphasized the transformative impact of AI on the workforce, suggesting a need for education systems to prepare young individuals for this change, others opposed such a workforce-preparation framework, especially for early childhood education (ECE). They

argued that predicting future job landscapes is uncertain, asserting that for children under five, developing cognitive, social-emotional, physical, communication, and executive functioning skills should be prioritized. Some experts expressed concerns about how unequal access to AI learning might exacerbate existing inequities, though this was disputed due to the lack of evidence on the significance of early exposure in ECE. Multiple members of the K12 Computing Education panel argued strongly against a workforce-preparation emphasis, arguing that in K12 CS, workforce preparation has led to short-sighted goals (e.g., learning to code) and an avoidance of the cultural and political potential of computing.

2.4.3 Protecting Childhood

The panelists discussed the concept of protecting childhood and the special character of in early education. Some early childhood educators emphasized the need to safeguard the flexible, holistic values that underpin early childhood education from becoming overly content-driven, highlighting that "childhood is messy." Concerns were raised about the excessive reliance on digitally-mediated experiences and the impacts of AI on human nature, suggesting that these could distract from essential developmental priorities, like play. As one panelist put it, "The priority should be play." However, from a posthuman perspective, some panelists argued against the notion of preserving humanity, suggesting instead that AI's cognitive and social interactions are merely new forms of humanity. One perspective challenged the assumption that lacking access to AI is inherently negative, likening it to the excessive consumption of candy, which is not necessarily beneficial.

2.4.4 Citizenship

In discussions about citizenship and the role of AI within societal frameworks, several experts posited that active and informed political participation necessitated some level of AI literacy. While some advocated for AI media literacy, highlighting the need to educate the public on how AI can influence media consumption, others emphasized the necessity of understanding the broader political implications and impacts of AI technologies. An important clarification made was the statement that "AI cognition and social interaction are just different forms of humanity," suggesting the need for recognition that cognition extended into AI constitutes a distinct entity that demands acknowledgment within societal discourse.

3. Who: Developmental Considerations

Panelists disagreed on when it was most appropriate to start teaching AI, some arguing that children may not yet have developed the required executive function, while others argued that AI is now ubiquitous, and that starting late may set them back. Childrens' developmental trajectory was discussed and some concerns were raised about the potential impact of AI in their lives. Developmental appropriateness was also criticized as a paradigm for thinking about when to introduce AI, as what is developmentally-appropriate is culturally and historically situated and shaped.

3.1 When to Start

In the debate over when to introduce AI to children, experts offered divergent opinions. Some advocated for delaying introduction as long as possible, emphasizing the necessity for children to first develop foundational cognitive skills such as theory of mind, working memory, and executive function. This group highlighted the inadequate research on the developmental appropriateness

of AI and questioned the potential drawbacks of late exposure. Conversely, other experts argued for an earlier introduction, suggesting that children as young as four might already be behind. They pointed out that children are already encountering AI in various forms and therefore need instruction on its use. One argument claimed that "any child could be taught anything at any age in some intellectually honest form," suggesting that age should not be a limiting factor in AI education.

3.2 Developmental Opportunities

The group of experts discussed the developmental opportunities for introducing AI to children, highlighting several key considerations. There was a recognized importance in differentiating between robots and humans, with some experts expressing concern about AI anthropomorphism. They argued that AI relationships differ fundamentally from human interactions, citing that while human relationships are often unpredictable and involve disagreements, AI can be designed to be always agreeable. The experts also noted that online spaces provide highly creative and engaging environments for some neurodivergent children, suggesting that limiting play to in-person contexts could be detrimental. It was observed that young children approach technology with a positive, eager mindset, perceiving it initially as magical and then gradually building their understanding as they mature. Furthermore, the experts emphasized that children's learning significantly shapes their behavior, using examples like learning about germs and vaccines influencing hygiene practices and vaccination choices. They agreed that children are fast learners, rapidly assimilating information, and acknowledged that starting cumulative learning at an early age can give them a developmental advantage.

3.3 Developmental Constraints

The experts discussed the developmental constraints on introducing AI to young children, noting that these children are still grappling with foundational skills such as a sense of self, theory of mind, and reading. Some experts questioned whether young children possess the cognitive readiness for AI, emphasizing the importance of their working memory, executive function, and theory of mind as necessary prerequisites. Despite these concerns, an argument was made suggesting that children might be capable of learning abstract concepts, like AI, in the same way they understand invisible entities such as germs, which challenges the focus on hands-on learning in early childhood education. This points to a potential for incorporating AI education in a manner that aligns with children's existing learning processes, although the debate remains open on their readiness.

3.4 AI's Potential Impact on Young Children

Experts expressed concerns about AI's potential impact on young children, particularly the risk of AI interfering with human relationships. They noted that children might prefer AI personas over real people, contributing to the observation that young people are forming fewer close friendships. Additionally, there was an argument that as history shows, the technology available in a given era significantly influences brain development, and with AI's ubiquity today, children's brains are evolving differently. While technology immersion is necessary for building proficiency and understanding, some experts warned that children might be disadvantaged without it. However, there was agreement that children are particularly susceptible to digital addiction because these tools are designed to be engaging, and young children often lack self-regulation skills. Moreover,

the requirement for AI to collect vast amounts of data prompted concerns regarding constant surveillance and its impact on children's lives.

4. How: Effective and Equitable AI Learning

4.1 Infrastructure

When answering the third question about "fostering effective and equitable AI education in early childhood," panelists discussed the need for a robust infrastructure including capacity building, system updating, and expanding beyond formal education settings.

4.1.1 Capacity Buidling

In discussing the topic of capacity-building for AI education, experts noted that parents often face challenges due to a lack of understanding about AI, which complicates their role in teaching it. The majority of panelists suggested that parents should be empowered and engaged in decision-making about AI education to ensure they help select technologies and programs that are best suited to their children's needs. Schools were also identified as lacking the necessary capacity and information to make informed decisions about AI. Some experts recommended providing assistance to schools by reflecting educational values and ensuring a democratic technology procurement process. This, they argued, would help navigate the challenges posed by limited departmental knowledge and time constraints. Moreover, to protect the pedagogical integrity of AI education, experts emphasized the need to shield technology choices and content from the influence of vendors and for-profit companies, prioritizing students' interests over commercial motives. Concerns were also raised about the potential of AI integration to exacerbate skill gaps among teachers, underlining the urgency for targeted professional development to enhance AI literacy. Panelists also advocated for cost-effective technological solutions to reduce teachers' workloads, thereby reinforcing and expanding their roles in teaching AI. Collaborative efforts were deemed essential in preparing teachers with AI awareness and relevant skills, culminating in a more inclusive and impactful educational paradigm.

4.1.2 System Updating

Experts emphasized the need for a dedicated system to audit the AI learning process, which they asserted was crucial for safeguarding children's development through rigorous screening processes. They advocated for a model of democratic monitoring to ensure the ethical use of AI, thereby promoting transparency and accountability to effectively mitigate potential biases and inaccuracies. Additionally, the experts proposed the implementation of independent certification for AI education qualifications, particularly targeting teachers, as a means to establish standardized benchmarks. This, they argued, would serve to enhance trust among all stakeholders involved in AI education.

4.1.3 Expanding Beyond Formal Education Settings

While the project focuses more on formal schooling, experts brought up other settings for introducing AI learning. Some experts advocated for using prevalent AI products in daily and home settings for education, citing their convenience and accessibility. However, others believed home-based AI education is unnecessary, believing it lacks the depth of wisdom inherited from previous generations, which would be a big challenge for parents. Some experts noticed many potential

AI education opportunities and the possibility of constructing specific after-school programs in different public learning environments, such as libraries and parks. In addition, many topics in community resources are worth utilizing for AI education.

4.2 Learning Theories & Roles of Learners and Teachers

Some experts questioned how AI may challenge existing schooling learning. It offers a transformative opportunity, but it may also trigger a zero-sum game, which may push out the traditional educational content. Specifically, it may offer personalized instruction and tailored support and enhance education while diminishing traditional learning. Nonetheless, experts cited some existing theories to guide AI learning and discussed children's and teachers' roles.

4.2.1 Learning Theories

In discussing learning theories applicable to AI education, experts emphasized various approaches that align with young children's developmental stages and learning styles. The Developmentally Appropriate Practices (DAP) advocated by NAEYC suggested that early childhood education should be tailored to children's developmental levels and cultural backgrounds. The concept of the "100 languages" from Reggio Emilia was highlighted, encouraging young learners to explore their world and communicate via diverse symbolic modes, including art, movement, and music. Papert's constructionism (1980) was noted for its focus on learning through the creation of tangible or mental representations, thereby facilitating deep learning by allowing children to build meaningful projects and engage actively with materials. In contrast, Piaget's constructivism emphasized knowledge construction through real-world interaction. An expert drew on Bloom's taxonomy to recommend a progression in AI education from fundamental concepts towards creative application. Furthermore, some AI experts proposed the use of machine learning models that simplify AI concepts for children, making use of interactive tools like animated horse faces or facial expressions to demystify complex ideas. This reflects an inclination towards blending traditional educational theories with modern technological advancements to enhance AI learning for young children.

4.2.2 Children's Agency

The experts highlighted the importance of acknowledging children's agency and capabilities in understanding and interacting with AI, positing that educators should incorporate children's perspectives and pre-existing insights into the learning process. They recommended a balanced approach between adult guidance and children's independent exploration to foster curiosity and self-initiated learning, emphasizing the encouragement of children's active participation and curiosity. This approach was seen as a means to promote exploration, self-directed development, and the pursuit of personal interests, with AI serving as a supportive tool. Experts also noted that, as digital natives, children often develop technology-related skills more rapidly than adults, suggesting a potential shift in the dynamics of teaching and learning within AI education. Some experts advocated for the "100 languages" philosophy from Reggio Emilia, underscoring the belief in children's ability to construct their own worlds and the significance of amplifying children's voices and expressions in AI educational settings.

4.2.3 Teachers' Role

Experts conveyed that the integration of AI in education has significantly transformed the traditional role of teachers, positioning them as pivotal figures responsible for the ethical navigation

and application of AI tools. They stressed that teachers must fill accountability gaps and provide scientific guidance on AI's implications. Furthermore, the discussions underscored the influence of educators' personal values, which orient students towards understanding AI's broader impact on society. This engagement between teachers and students is crucial for shaping AI decision-making and learning processes. Additionally, some experts advocated for a more personalized approach in AI education, wherein teachers provide individualized support to accommodate diverse learning paces and preferences, thereby enhancing students' overall learning experience.

4.3 Pedagogical Considerations

Experts stressed the importance of integrating AI into education thoughtfully, underscoring the necessity for practical resources and ethical standards to harness its benefits fully. They acknowledged that education goes beyond school walls, highlighting the critical role of family and community involvement. They debated whether we should position AI in the curriculum as a standalone subject or integrated within STEAM and existing curriculum content.

4.3.1 Principles

Experts expressed the need for careful consideration prior to implementing actions that could have irreversible impacts on young children. They emphasized that all educational techniques should be grounded in evidence-based practice, advocating for empirical research at both school and research levels to fully understand the effects of such practices and to enable effective learning. Furthermore, to foster a deep understanding of AI concepts among children, experts recommended that teachers employ clear and explicit narratives to communicate the advantages and disadvantages of AI, thereby enhancing critical engagement and comprehension. Promoting a positive influence of AI on children was deemed crucial, as it would shape their future attitudes towards technology, nurturing curiosity, openness, and responsible tech engagement. In addition, the experts suggested that AI teaching should connect with children's own experiences, thus facilitating meaningful learning and allowing students to relate AI concepts to their personal development, interests, and goals, ultimately encouraging self-expression and the pursuit of identity.

4.3.2 Materials

Experts argued for several approaches to developing pedagogical materials for early childhood AI education. They emphasized incorporating children-friendly elements, such as popular puppets, Disney characters, and favorite animals, to create interfaces and tools appealing to young learners. The majority of experts advocated for the use of embodied tools in AI learning, which involve hands-on experiences through unplugged, tangible interfaces and physical toys. This approach stood in contrast to abstract methods and was seen as a way to make AI education more accessible by illustrating practical applications. However, there was also support for maintaining flexibility in tool selection, with suggestions ranging from chatbots and robots to interactive storytelling and AI-enhanced books, including daily tools like ChatGPT. Furthermore, the aspect of safety was crucial, with experts recommending controlled access to AI tools, akin to YouTube's age-based permission settings, highlighting the need for a cautious stance to ensure safe AI interactions for learners.

4.3.3 Curriculum

In discussing the curriculum for early childhood AI education, a few experts proposed treating AI education as a separate domain, arguing that it possesses its own systematic structure that should

be specifically tailored for younger learners. In contrast, some experts advocated for integrating AI into traditional early childhood education (ECE) areas, suggesting that engaging with AI, such as through robots, could enhance students' social-emotional learning and improve reading skills via AI-driven storytelling systems. Despite differing views on its place within the curriculum, several experts agreed that AI education was already present in STEM education and highlighted the necessity of incorporating other STEM disciplines when designing AI education curriculums. This approach, they believed, would provide a comprehensive framework that aligns with existing early childhood educational themes.

4.3.4 Pedagogical Strategies

Experts recommended Developmentally Appropriate Practice (DAP) for AI education in early childhood, emphasizing that lessons should cater to children's developmental stages, individual traits, and interests. They advised integrating age-suitable AI content with children's curiosity and creativity, simplifying complex AI concepts, and tailoring communication to developmental levels while considering children's individual and cultural backgrounds. The significance of guided learning and scaffolding within the Zone of Proximal Development (ZPD) was highlighted, with educators encouraged to identify teachable moments to foster autonomy and learning efficiency. Play-based learning was largely favored as a means to introduce AI, by harnessing children's imaginative play and promoting independence with support. A participatory design was advocated to create personalized learning experiences, involving community, family, educators, and children. Cultural responsiveness was emphasized, with a focus on respecting diverse beliefs, such as the perception of machines in different cultures, and considering societal and political impacts, including regional data privacy norms. Experts suggested an "access-based" approach, utilizing available resources and everyday life experiences to inclusively empower learning. The interdisciplinary integration of AI education with other STEM fields was recommended to enhance learning, alongside the benefits of direct human interaction, hands-on activities, and active media engagement.

4.4.5 Assessment

Experts discussed the importance of clearly defining and implementing effective assessment strategies to evaluate AI learning outcomes in early childhood education. They emphasized the challenges associated with assessing AI learning, highlighting issues such as the difficulty in identifying effective metrics or content, the scarcity of established assessment models, and skepticism about the applicability of traditional methods. Many experts advocated for a multi-method approach, suggesting that it would allow for a more comprehensive and equitable evaluation of young learners. There was a shared consensus that innovative assessment strategies are necessary to address these challenges, underscoring the need for further research and development in this area.

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