AI-Play: A Framework for Teaching Artificial Intelligence Concepts through Unplugged Activities in Early Childhood Education

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Abstract:
AI is increasingly present in young children's lives, yet most AI literacy guidance targets older students and relies on technical approaches unsuitable for early childhood. This paper introduces AI-Play, a play-based, unplugged framework that translates core AI ideas into developmentally appropriate learning experiences for young children, educators, and families. AI-Play organizes AI literacy into four components: AI Body (AI as a system built from parts), AI Food (AI learns from examples), AI Brain (AI improves through patterns and feedback), and a Pre/Post-AI ethical lens emphasizing human responsibility, fairness, and agency. The framework was derived from a synthesis of major AI literacy standards and refined through expert feedback from early childhood educational technologists. AI-Play was implemented through Hour of Code family activities. Child reflections and parent surveys indicated high engagement and emerging understanding that AI is human-made, learns from examples, and can make mistakes. Results suggest that early AI literacy can be introduced effectively through play without technical tools.

Introduction

Artificial intelligence (AI) is now part of children's daily lives through toys, media, voice assistants, and classroom technologies [1, 2]. Children begin forming ideas about AI long before they receive any formal instruction [3, 4]. Without guidance, these early ideas often lead to misconceptions—such as thinking AI is alive, or always correct [3, 4]. Early childhood education therefore plays an important role in helping children build accurate, safe, and ethical understandings of AI from the start [1, 5]. Although many AI literacy standards and frameworks exist for K–12 education, they are not developmentally designed for early childhood learners [5-7]. Most assume abstract reasoning, reading ability, or access to digital tools, and they provide little guidance for how educators and families can introduce AI concepts through play-based learning [1, 8, 9]. This creates a gap between what the field agrees children should understand about AI and how those ideas can be taught in Pre-K through early elementary settings.

To address this gap, this paper introduces AI-Play, a pedagogical framework that translates foundational AI concepts into play-based, developmentally appropriate learning experiences. Rather than presenting AI through algorithms or technical construction, AI-Play reorganizes AI literacy into four child-accessible components: how AI senses and interacts with the world (AI Body), what AI learns from (AI Food), how AI changes behavior through learning (AI Brain), and an ethical and agency lens that frames all understanding of AI (Pre/Post-AI with Ethics). This structure allows children to explore AI through movement, role-play, examples, and guided reflection while also developing early awareness of fairness, responsibility, and the fallibility of technology. The framework was first reviewed by early childhood educational technologists to examine its clarity, usability, and developmental appropriateness. Their feedback led to revisions in the visual representation and pedagogical organization of the model. Following this expert refinement, AI-Play was used to design a series of unplugged and low-tech activities for a public Hour of Code family event. These activities were implemented with children and parents and were met with high engagement and positive feedback, demonstrating that AI-Play can be translated into practical, play-based lessons that support children's understanding of AI concepts while remaining accessible to non-technical educators and families.

This paper makes three contributions. First, it synthesizes recurring AI literacy competencies from widely referenced standards, frameworks, and policy guidance and identifies a persistent lack of developmentally grounded guidance for Pre-K–K2 learners. Second, it presents AI-Play as a conceptual and pedagogical bridge that translates these competencies into early childhood–appropriate learning progressions and teacher moves. Third, it reports an initial implementation and evaluation of AI-Play through a family-centered Hour of Code event, using parent surveys and child reflection sheets to examine engagement, perceived learning, and the usability of the activities for at-home replication. Together, these contributions aim to advance early childhood AI literacy by offering a practical framework that is both pedagogically faithful to early learning principles and conceptually aligned with emerging AI literacy expectations.

Method

Design

The goal of this work is to develop a framework that is developmentally appropriate informed by methods used in prior research [10-14], to create the AI-Play framework. This framework is intended to help early childhood educators teach AI concepts in a basic, simple, and pedagogically meaningful way that aligns with children's developmental abilities. The study followed an iterative design and validation process as illustrated in Figure 1.

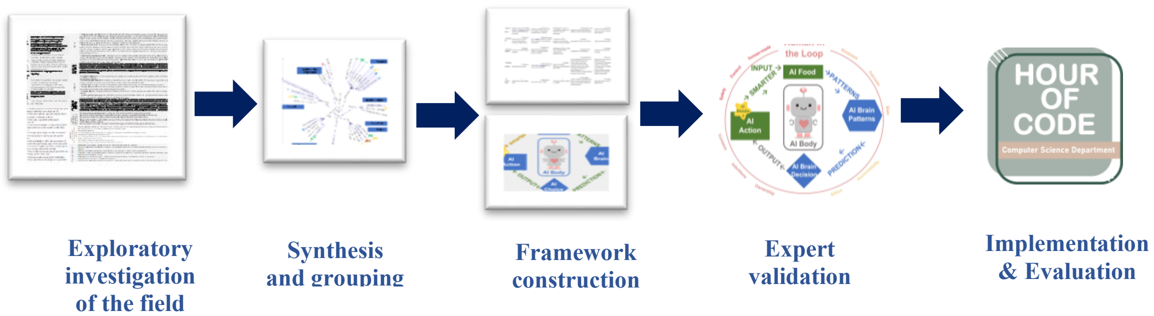

Figure 1. Conceptual Process Used to Develop the AI-Play Framework

The following five stages were followed to develop the framework:

1. **Exploratory investigation of the field** (literature, standards, and policy guidance) to identify AI literacy competencies relevant to young learners and to determine where gaps exist for Pre-K–K2.
2. **Synthesis and grouping** of recurring concepts into early childhood–appropriate competencies.
3. **Framework construction (AI-Play)** by reorganizing AI literacy into play-based pedagogical stages.
4. **Expert validation** through early childhood educator/educational expert feedback and framework revision.
5. **Implementation and evaluation** of AI-Play through the design of Hour of Code family activities and the collection of parent and parent–child survey feedback focusing on engagement and perceived learning.

Results

Keywords, Database, and Criteria

Two databases were used for this exploratory review: the ACM Digital Library to locate peer-reviewed research papers and Google Scholar to identify policy documents, standards, and framework reports. These sources were selected to ensure coverage of both academic research and the broader standards and policy landscape that informs AI education. The following keyword string was used in the ACM Digital Library: ("AI literacy" OR "AI competencies" OR "AI standards" OR "AI framework" OR "AI guidelines" OR UNESCO OR OECD OR "AI4K12") AND ("early childhood" OR preschool OR "pre-K" OR "K–12") NOT (algorithm OR neural OR "deep learning" OR "high school" OR "middle school"). Sources were included if they discussed AI literacy, AI competencies, or AI educational frameworks; referenced established standards, policy guidance, or conceptual models; and had relevance or implications for early childhood or early elementary learners, even if they were not explicitly designed for them. Sources were excluded if they focused primarily on technical AI implementation (e.g., algorithms, neural networks, deep learning methods), centered on high school, higher education, or adult learners, or were unrelated to AI literacy, pedagogy, standards, or educational guidance. The results were filtered by reviewing titles, abstracts, and content. The selected sources included conference papers and proceedings (in English), government and official reports, and scholarly journal articles. Priority was given to sources published from 2023 onward to capture the most recent developments, while still including foundational standards and frameworks published earlier when relevant. A small number of sources outside the K–12 context (e.g., adult and informal AI literacy studies) were included when they provided transferable insights into how non-technical audiences understand AI concepts

Exploratory Investigation of the Field

The purpose of this search was to understand the current landscape of AI literacy guidance and to determine whether developmentally appropriate direction exists for early childhood education. The initial search yielded 145 papers and documents. These results were systematically filtered through multiple stages. Titles and abstracts were first reviewed to remove work focused on highly technical AI implementation, secondary or higher education contexts, or topics unrelated to AI literacy and pedagogy. The remaining sources were then examined through content review to identify those that discussed AI literacy, referenced established standards or frameworks, or contained implications relevant to early childhood learners. Additional policy and standards documents were identified through Google Scholar to ensure representation of widely cited frameworks that may not appear in academic databases. Through this screening process, the original set of 145 results was reduced to 23 key papers and documents. These sources represent major AI literacy standards, conceptual frameworks, policy guidance, and child-centered perspectives. Collectively, they informed the development of the AI-Play framework and highlighted a critical gap in developmentally grounded AI literacy guidance for early childhood education. The final set of sources is summarized in Table 1.

Table 1. Summary of Selected Papers and Documents Informing the Exploratory Review

#	*Paper Title*	*Authors*	*AI Literacy/ Standard?*	*Type of Contribution*	*AI Competencies Covered*	*References to Existing Literacy Standards*	*Pre-K / K–2 Focus*
[15]	Co-Designing AI Literacy for K–12 Education	Linda Mannila	No	Pedagogical process model	Foundational AI concepts; ethics	Long & Magerko; UNESCO; AI4K12	No
[16]	Generating AI Literacy MCQs	Wang, Xiao, Tseng	No	Assessment methodology	Implicit	AI4K12	No

[17]	Teaching Responsible AI Literacy in Schools	Robertson et al.	Partial	Curriculum & PD	Responsible AI; ethics	AI4K12; WEF	No
[18]	Building Global AI Literacy	Renzella et al.	No	Teacher PD	Teacher AI awareness	UNESCO	No
[19]	AI Literacy: Finding Common Threads	Long et al.	No	Conceptual synthesis	Conceptual	Long & Magerko	No
[20]	Measuring Teacher Self-Efficacy	Whyte et al.	No	Measurement	Teacher confidence	AI4K12	No
[21]	AI Literacy Framework for Developing Nations	Kathala, Palakurthi	Yes	Comprehensive framework	Knowledge; skills; ethics	AI4K12; UNESCO; OECD	No
[22]	Booklet-Based Design to support AI literacy	Xie et al.	No	Pedagogical method	Ethical AI	Long & Magerko	No
[23]	Organizing State-Level Efforts	Gardner-McCune et al.	Partial	Standards implementation	AI4K12 Big Ideas	AI4K12; CSTA	Partial
[24]	Are You Ready to Teach AI?	Addo	No	Teacher study	Not defined	AI4K12	No
[25]	AI for K–12: Making Room	Gardner-McCune et al.	Yes (foundational)	Proto-standard	Five Big Ideas	AAAI & CSTA	Partial
[26]	Knowledge Explorer	Faisal et al.	No	AI tool	None	None	No
[27]	EC AI Guidelines & Acts	Quille et al.	No	Policy aggregation	Ethical AI	European Commission	Policy
[28]	Exploring What People Need to Know	Xie et al.	No	Meta-analysis	Aggregated competencies	AI4K12; Long & Magerko	No
[29]	Developing Young Children's AI Literacy	Mabberi	No	Community-based EC	AI awareness; ethics	None	Yes
[30]	How States Prepare for 4IR	Gardner-McCune, Touretzky	No	Policy landscape	Not defined	State initiatives	Implicit
[31]	Conceptualizing K–2 Educators around AI	Vandenberg et al.	No (integrative)	K–2 AI pre-literacy	AI4K12; Digital Promise	AI4K12; Digital Promise	Yes
[32]	Introduction of AI & Data Literacy in CS Teacher Ed	Olari et al.	No	Teacher PD	Rule-based AI; ML; data	Long & Magerko; UNESCO	No
[33]	Designing AI for Children's Well-Being	Landesman et al.	No	Child-centered AI design	Ethical awareness	RITEC; AAAI	Yes
[34]	When Schools Meet Artificial Intelligence in Hong Kong	Wong, Ma, Huen	**No**	**Exploratory K–12 AI education case study**	ML basics; data; ethics (implicit)	CSTA; AAAI (early AI4K12 vision); HK Education Bureau	Exploratory
[35]	AI Literacy Education for Older Adults: Motivations, Challenges and Preferences	Tang et al.	**No**	**Empirical needs analysis (survey study)**	AI awareness; practical AI use; risk awareness (scams, misinformation); ethical concerns (implicit)	Long & Magerko (CHI); Ng et al.; Yi (academic conceptual frameworks)	No
[36]	"AI Training Should Be for Everyone": Informal Training on AI	Kasinidou et al.	**No**	**Informal AI education & program evaluation**	AI awareness; practical AI use; critical understanding; ethical concerns (high-level)	Academic AI literacy & public engagement literature (no formal standards)	No

Synthesis and Grouping

Analysis of the selected papers and documents revealed that most references to AI literacy, competencies, and educational guidance consistently point to a small set of widely recognized standards, frameworks, and policy documents. These frameworks collectively shape current understandings of AI literacy across research, policy, and educational practice, yet they vary considerably in purpose, audience, and pedagogical specificity. Across the 23 selected sources, the following frameworks and guidance were repeatedly referenced as foundational to AI literacy discussions:

1. AI4K12 – Five Big Ideas in AI (AAAI & CSTA) [37]
2. Long & Magerko AI Literacy Competency Framework (CHI) [3]
3. Digital Promise AI Literacy Framework [4]
4. CSTA K–12 Computer Science Standards (AI-integrated) [38]
5. UNESCO AI & Education Frameworks [39]
6. OECD AI & Digital Literacy Frameworks [40]
7. European Commission AI & Digital Education Frameworks [27]
8. TeachAI Guidance [41]
9. RITEC (UNICEF & LEGO) child well-being framework (adjacent) [42]

The AI4K12 – Five Big Ideas in AI framework provides one of the most widely recognized conceptual foundations for AI literacy in K–12 education. It organizes AI understanding into five areas: Perception (how AI systems sense the world through images, sound, and other inputs), Representation and Reasoning (how AI systems internally represent information and use rules or models to make decisions), Learning (how AI systems improve by learning from data and examples), Natural Interaction (how humans communicate with AI systems), and Societal Impact (ethical and social implications including fairness and bias). While AI4K12 conceptually spans early grades, it primarily defines what students should understand and does not explain how these ideas can be introduced through developmentally appropriate, play-based experiences for young children.

The Long and Magerko AI Literacy Competency Framework approaches AI literacy from a human–computer interaction perspective, defining it as a multidimensional set of knowledge, skills, and dispositions needed to understand, evaluate, and engage with AI systems in everyday life. The framework emphasizes recognizing AI capabilities and limitations, understanding how AI systems are trained using data, distinguishing human intelligence from machine intelligence, critically evaluating AI outputs, and understanding ethical and societal impacts. Although influential in shaping later AI education research, the framework remains conceptual and descriptive, offering little guidance on instructional design or developmental progression for early learners.

The Digital Promise AI Literacy Framework frames AI literacy through learner agency and responsible interaction with AI tools. It emphasizes understanding AI concepts such as data, models, and decision-making, using AI tools thoughtfully, and evaluating AI systems in terms of fairness, accuracy, and transparency. The framework is accessible for classroom use but intentionally broad, leaving educators to determine how these competencies translate into age-appropriate learning experiences, particularly for early childhood settings.

The CSTA K–12 Computer Science Standards embed AI-related ideas within broader computer science strands such as data and analysis, algorithms and programming, computing systems, and impacts of computing. These strands support foundational AI understanding by emphasizing how data informs automated decisions and how computing systems affect individuals and society. However, because AI is treated as an extension of computer science rather than a distinct literacy domain, the standards offer limited direct guidance for introducing AI concepts to young children in developmentally meaningful ways.

At the policy level, UNESCO's AI and Education frameworks position AI literacy as a global priority grounded in human rights, inclusion, and ethical responsibility. These frameworks emphasize foundational understanding of AI, awareness of data privacy and security, critical evaluation of AI systems, and ethical principles such as fairness and accountability. However, they operate at a systems and policy level and do not provide pedagogical or developmental direction for classroom practice.

Similarly, the OECD AI and Digital Literacy frameworks situate AI literacy within broader digital and future-ready competencies needed for participation in AI-enabled societies. They emphasize adaptability, critical thinking, and lifelong learning related to AI technologies but focus primarily on competency development rather than instructional approaches, particularly for early childhood learners.

The European Commission's AI and Digital Education frameworks approach AI literacy through ethical governance, digital competence, and regulatory responsibility. Anchored in initiatives such as the Ethics Guidelines for Trustworthy AI, the AI Act, and DigComp, these frameworks emphasize data protection, human oversight, risk awareness, and ethical AI use. While providing strong normative guidance, they offer little support for translating these ideas into classroom pedagogy for young children.

TeachAI provides teacher-facing guidance for integrating AI tools responsibly in classrooms. It emphasizes transparency, ethical use, and critical questioning of AI-generated content, positioning teachers as mediators of students' AI understanding. However, it does not define developmental progressions or age-specific learning outcomes.

Finally, the RITEC framework, developed by UNICEF and the LEGO Group, focuses on children's well-being, safety, agency, and inclusion in digital environments. Although not an AI literacy framework, it provides essential child-centered principles—such as fairness, protection from harm, and adult responsibility—that are highly relevant when introducing AI concepts to young learners.

Framework Construction

Analysis of the identified standards, frameworks, and policy documents revealed strong agreement in the field regarding ethical awareness, societal impact, and broad conceptual understanding of artificial intelligence. However, these frameworks differ significantly in purpose, audience, and level of pedagogical specificity. Frameworks such as AI4K12 and CSTA provide concrete conceptual guidance for K–12 curriculum design but remain conceptually grounded rather than developmentally grounded, offering limited support for early childhood learners. In contrast, policy-oriented frameworks such as UNESCO, OECD, and the European Commission emphasize governance, equity, and workforce readiness without offering instructional guidance. Child-centered guidance such as RITEC prioritizes well-being and children's rights but does not define learning outcomes or instructional approaches for teaching AI concepts. Collectively, these frameworks reveal a critical gap: the absence of a formal, developmentally appropriate AI literacy structure for early childhood education. Among existing AI literacy frameworks, only AI4K12, Digital Promise, and Long & Magerko provide conceptual elements that can be meaningfully interpreted for early childhood contexts. However, none were designed specifically for Pre-K–K2 learners, and none provide pedagogically grounded guidance for translating AI competencies into play-based early learning experiences.

To address this gap, the competencies emphasized across all frameworks were systematically analyzed and compared. Recurring themes, learning expectations, and conceptual priorities were extracted and grouped into categories that could be meaningfully interpreted for young learners. This synthesis revealed a consistent set of core AI literacy competencies present across nearly all standards, even though they are not instructionally defined for early childhood. These competencies and their presence across major frameworks are summarized in Table 2.

Table 2. Synthesized AI Literacy Competencies Across Frameworks

AI COMPETENCY	DESCRIPTION	APPEARS OR IS IMPLIED IN	NOT INSTRUCTIONALLY DEFINED IN
UNDERSTANDING WHAT AI IS (AND IS NOT)	Learners understand that AI is human-made, not magical, does not think or feel, and operates based on rules or learned patterns rather than intention or emotion.	AI4K12; Long & Magerko; Digital Promise; UNESCO; OECD; European Commission; TeachAI (implicit in RITEC through human responsibility)	CSTA (implicit only); RITEC (protective, not instructional)
CONCEPTUAL UNDERSTANDING OF HOW AI WORKS	Learners understand at a high level that AI systems sense inputs, process information, and make decisions based on representations and patterns rather than human reasoning.	AI4K12; Long & Magerko; Digital Promise; CSTA; UNESCO; OECD	European Commission; RITEC; TeachAI (focuses on use, not mechanisms)
DATA AWARENESS	Learners recognize that AI systems require data to learn, that data comes from people and the world, and that data quality affects outcomes and decisions.	AI4K12; Long & Magerko; Digital Promise; CSTA; UNESCO; OECD	European Commission (governance focus only); RITEC (safety-focused, not learning-focused)
LEARNING FROM EXAMPLES (AI LEARNING)	Learners understand that AI systems improve by learning from examples, can make mistakes, and depend on feedback or correction provided by people.	AI4K12; Long & Magerko; Digital Promise; CSTA	UNESCO; OECD; European Commission; RITEC
HUMAN–AI INTERACTION	Learners can recognize and engage with AI systems through language, voice, images, or other interfaces, and understand that these interactions are designed by people.	AI4K12; Digital Promise; Long & Magerko; TeachAI	UNESCO; OECD; European Commission; RITEC

CRITICAL EVALUATION OF AI OUTPUTS	Learners can question AI decisions, identify errors or bias, avoid overtrust, and understand that AI outputs are not always correct or neutral.	Long & Magerko; Digital Promise; UNESCO; OECD; European Commission; TeachAI	AI4K12 (conceptual but limited instructional detail); CSTA; RITEC
ETHICS, FAIRNESS, AND SOCIAL IMPACT	Learners understand that AI can affect people differently, raise issues of fairness and bias, and have social, cultural, and ethical consequences.	**ALL frameworks**: AI4K12; Long & Magerko; Digital Promise; CSTA; UNESCO; OECD; European Commission; TeachAI; RITEC	None (universally emphasized, but pedagogically underdeveloped for EC)
HUMAN AGENCY AND RESPONSIBILITY	Learners recognize that humans design, train, deploy, and are responsible for AI systems and their impacts.	Long & Magerko; UNESCO; European Commission; TeachAI; RITEC (strong emphasis)	AI4K12; CSTA; OECD (implicit but not explicit learning goals)

Table 2 demonstrates strong agreement across frameworks regarding what learners should understand about AI, while simultaneously showing that these competencies are rarely defined in developmentally appropriate or instructionally grounded ways for early childhood education. The AI-Play framework was therefore constructed by reorganizing these competencies into stages that align with how young children naturally learn through play, interaction, cause–effect exploration, and social reasoning. This process did not introduce new AI competencies; rather, it translated and sequenced existing ones into a developmentally appropriate pedagogical structure. The framework stages describe a pathway through which children build foundational understanding of artificial intelligence. In the Pre-AI stage, children learn that humans are in control and that AI is not magic, developing a sense of agency and demystification. In the AI Body stage, they explore the idea that AI has “eyes,” “ears,” and “actions,” introducing the concept of perception and interaction. In the AI Food stage, children understand that AI learns from examples, emphasizing the role of data. In the AI Brain stage, they observe that AI looks for patterns, changes behavior based on examples, and can make mistakes, highlighting how learning occurs. Finally, the Ethics stage focuses on fairness, kindness, responsibility, and the societal implications of AI, forming an early ethical understanding that overlays all other stages. Each AI-Play stage directly corresponds to the competencies identified in Table 2. Pre-AI draws from understanding what AI is and recognizing human responsibility. AI Body reflects conceptual understanding of AI inputs, outputs, and human interaction. AI Food emerges from data awareness. AI Brain corresponds to learning from examples and critical evaluation of AI outputs. Ethics is grounded in fairness, bias awareness, and human accountability, which appear consistently across all major frameworks.

This reorganization is supported by early childhood learning theory. Dewey’s experiential learning emphasizes that children understand concepts through meaningful interaction rather than abstract explanation. Vygotsky’s social constructivism highlights learning through guided play and shared language within the child’s zone of proximal development. Young children cannot reason about algorithms or abstract representations, but they can understand examples, cause–effect, mistakes, fairness, and responsibility. Presenting AI through embodied interaction (AI Body), example-based play (AI Food), observation of change and error (AI Brain), and social reasoning (Ethics) aligns AI literacy with how children naturally construct understanding. Through this reorganization, AI literacy originally written for K–12 or policy audiences becomes teachable in Pre-K through early elementary contexts.

Expert Validation

Two early childhood educational technologists volunteered to review the AI-Play framework through open-ended discussions focused on clarity, usability, and developmental appropriateness for young learners. During these conversations, both experts reflected on the overall structure of the framework and noted that it effectively translates complex AI concepts into ideas that children can understand through play, interaction, and guided discussion. They emphasized that the metaphors used in the framework (AI Body, AI Food, AI Brain) align well with how young children interpret the world through tangible experiences, cause–effect relationships, and examples rather than abstract explanations.

Feedback from the experts then focused on refinements that would improve the pedagogical and visual representation of the model. The most significant recommendation concerned the placement of Ethics and Pre-AI (agency and demystification). The experts observed that presenting these as sequential steps could unintentionally suggest that ethics and human control occur only at specific points in the learning process. They recommended merging these elements and representing them as an outer lens surrounding all AI-Play stages. This modification emphasizes that fairness, responsibility, and human oversight are not stages of AI learning but perspectives that should be applied throughout every interaction with AI. The experts also highlighted the importance of explicitly representing how AI learns from mistakes, noting that children readily understand learning through repetition and correction. In response, a feedback loop was incorporated into the visual model to show how AI outputs can be reintroduced as inputs. This addition makes the iterative nature of AI learning visible and reinforces the idea that AI improves through guided examples and human feedback. Finally, the experts recommended assigning distinct colors to each AI-Play component to support visual differentiation between stages. This adjustment aids cognitive mapping for young learners, who rely heavily on visual cues to organize understanding.

These recommendations directly informed the refinement of the AI-Play visual representation shown in Figure 2. The revised model incorporates an outer ethical lens, the addition of a feedback loop, and color differentiation, resulting in a framework that is more visually intuitive and developmentally aligned with early childhood learning principles.

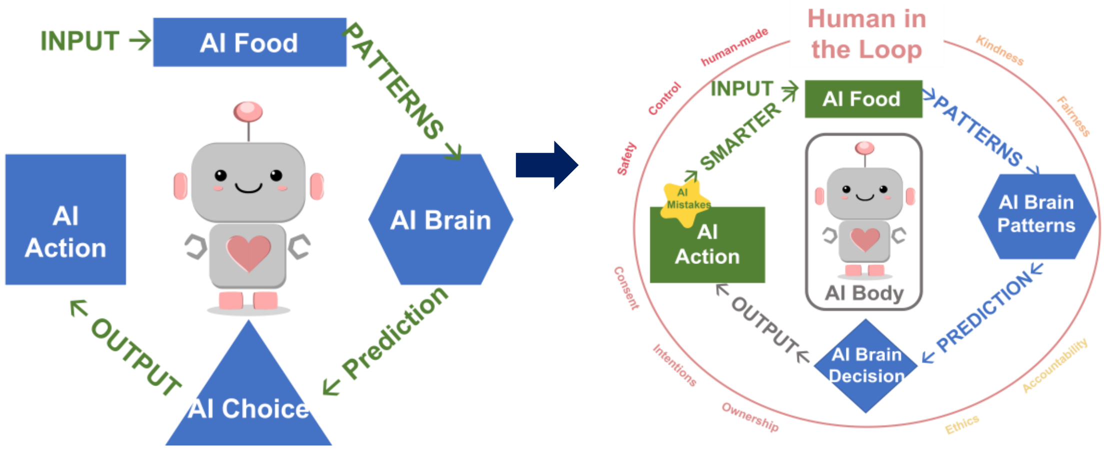

Figure 2. Before and after refinement of the AI-Play visual model based on expert feedback.

The AI-Play Pedagogical Model

The AI-Play framework consists of four core pedagogical components surrounded by an ethical and agency lens that applies across all learning experiences. These components are summarized in Table 3.

Table 3. AI-Play defines what children should understand at each developmental stage

AI-PLAY COMPONENT	TODDLERS (18–35 MONTHS)	PRESCHOOL (3–5 YEARS)	EARLY SCHOOL AGE (6–8 YEARS)	MIDDLE SCHOOL (11–12+ YEARS)	HIGH SCHOOL (14–18+ YEARS)
PRE/POST-AI (AGENCY & ETHICS)	Experience cause–effect	Say AI is made by people; not magic	Distinguish human vs AI abilities; discuss responsibility	Explain human oversight; compare rule-based vs learning-based AI	Analyze limits of AI autonomy; discuss misuse, power, and governance

AI BODY (INPUT/OUTPUT)	Notice objects respond to touch/sound	Identify inputs and outputs; act them out	Predict how changing input changes output	Explain sensing limits and sources of error	Analyze real-world sensing failures and reliability issues
AI BRAIN (LEARNING)	Trial-and-error play	Describe AI as "learning by trying"	Explain pattern-finding and improvement over time	Describe learning mechanisms (supervised, unsupervised, reinforcement) conceptually	Explain learning trade-offs, overfitting, confidence vs accuracy, and model limitations
AI FOOD (EXAMPLES/DATA)	Repeat actions to make things happen	Explain AI learns from examples	Distinguish good vs bad examples; discuss bias	Explain data quality, imbalance, and missing data	Evaluate datasets for bias, consent, and ethical collection

The Pre/Post AI component functions as the interpretive lens through which all AI learning experiences are understood. Rather than representing a discrete instructional step, this component frames every activity and discussion so that children consistently view artificial intelligence through the perspective of human agency and ethical responsibility. By positioning AI as a subject of inquiry rather than magic, children are guided to understand that these systems are created by people, do not think or feel, and remain subject to human oversight. Simultaneously, the framework introduces foundational ethical concepts, ensuring that as children interact with technology, they are grounded in ideas of fairness, care, safety, and accountability regarding AI behavior and decisions. Through repeated exposure to this lens across AI-Play activities, children develop *seven core* competencies expressed in developmentally appropriate language. (1) Demystification of AI (human-made, not magical), (2) Recognition of non-human agency (no feelings or intentions) (3) Awareness of human responsibility and oversight, (4) Understanding AI fallibility (AI can be wrong), (5) Development of appropriate trust and verification habits, (6) Fairness awareness and bias recognition and (7) Safety and privacy awareness. To operationalize this lens, educators adopt consistent routines before, during, and after AI-Play activities to reinforce these concepts. Before activities, educators establish classroom norms—such as "AI is made by people" or "Fairness matters"—and introduce critical vocabulary like tool, guess, mistake, and responsible. During engagement, educators utilize guiding prompts (e.g., "Who made this?", "Could it be wrong?", "Is it fair?") to normalize mistakes and encourage children to question the technology. Finally, after activities, brief reflection prompts help children connect their own actions to the AI's behavior, solidifying their understanding of human responsibility in correcting and guiding technological tools.

The AI Body component introduces children to the idea that artificial intelligence is a human-constructed system composed of parts that must work together. Rather than presenting AI as a single action or response, this component helps children develop a mental model of AI as a "body" composed of connected elements—what it receives (input), how it processes (brain), and what it produces (output). This idea is often introduced through analogy to the human body: just as people have parts that allow them to sense, eat, think, and act, AI systems have parts that perform similar functions, but these parts are invented, designed, and assembled by humans. Through guided play, role-play, and concrete representations, children explore how these parts must be connected for the system to function. They learn that AI does not act independently; it only works because humans have built and organized its components. This comparison to the human body helps children understand that AI behavior is not spontaneous or intelligent in a human sense, but the result of how its parts are arranged to work together as a system. Within AI-Play activities, children may physically represent these parts, act them out, or manipulate objects that symbolize sensing, processing, and responding. These experiences reinforce the idea that AI operates as a whole system rather than through isolated actions. Children begin to recognize that what AI does depends on how its parts are connected and that people are responsible for designing and organizing those parts. Through repeated exposure to this component, children develop several foundational understandings expressed in developmentally appropriate language: (1) AI has parts that must work together, (2) AI does not function unless its needed parts are connected, (3) what AI does depends on how its parts are arranged, and (4) humans invent, build, and organize these parts to make the system work. To operationalize this component, educators design activities where children assemble, represent, or simulate the "parts" of an AI system. Before activities, teachers introduce the idea that AI has a body made of connected pieces. During activities, educators prompt children with questions such as "What part is this?" "What happens if this part is missing?" and "How do these parts work together?" After activities, brief reflections help children articulate how the system only functioned because its parts were combined and arranged by people.

The AI Food component introduces children to the idea that artificial intelligence learns from information provided by people. Using the analogy of food for the body, this component helps children understand that just as humans need food to grow and function, AI systems require examples to "learn" how to behave. These examples—pictures, sounds, words, or actions—serve as the practice material from which AI systems form patterns and make future decisions. Through guided play and repeated interaction, children observe that when more examples are provided, the system's behavior changes. They also notice that incorrect or unbalanced examples can lead to mistakes, helping them understand that the quality of what AI is given affects how it behaves. This experience builds the foundational idea that AI does not possess knowledge on its own but depends entirely on the data it receives from people. Within AI-Play activities, children may "feed" the AI examples, observe how the system responds, and then modify those examples when mistakes occur. These interactions reinforce the understanding that AI learning is dependent on human input and that improving AI behavior requires providing better examples rather than expecting the system to "figure it out" independently. Through repeated exposure to this component, children develop several key understandings in developmentally appropriate language: (1) AI learns from examples given by people, (2) more examples help AI do better, (3) wrong examples cause AI to make mistakes, and (4) people can change the examples to help AI improve. To operationalize this component, educators design activities where children actively provide examples to a system and observe changes in its behavior. Before activities, teachers introduce the idea that AI needs examples to learn, similar to how people need food. During activities, educators ask questions such as "What examples did we give?" "Why did it make that mistake?" and "What new example can help it?" After activities, brief reflections help children connect the AI's behavior to the examples they provided, reinforcing the concept that data shapes AI learning.

The AI Brain component introduces children to the idea that artificial intelligence learns by adjusting its behavior through practice, feedback, and correction. Using the analogy of training a puppy, this component helps children understand that just as a puppy does not know how to behave at first but improves through repeated guidance, AI systems also improve when people show them what is correct and help them learn from mistakes. The puppy does not understand language or intentions; it learns through repetition, rewards, and correction. Similarly, AI does not think or understand; it changes how it responds based on the examples and feedback it receives. Within this component, the AI Brain is represented in two connected parts in the AI-Play model: AI Brain – Patterns and AI Brain – Decision. AI Brain – Patterns represents the learning phase. Here, the AI analyzes the examples it receives from AI Food and begins finding patterns across them. The system is not yet making decisions; instead, it is reorganizing itself internally based on repeated examples and corrections. This is where "training" occurs. AI Brain – Decision represents the application phase. Once patterns have been formed, the AI uses these learned patterns to produce an output or prediction when new input is received through the AI Body. In this phase, the AI is no longer learning but using what it has already learned to respond. Through guided play and repeated interaction, children observe this cycle in action. They may see the system make a guess (AI Brain – Decision), notice the error, and then provide a new example that helps the system reshape its patterns (AI Brain – Patterns). As this cycle repeats, children see that the AI becomes "better" not because it understands, but because it has been trained through repeated feedback. This makes the abstract concept of learning mechanisms concrete and developmentally accessible. Within AI-Play activities, these interactions reinforce the idea that AI learning is iterative and depends entirely on human guidance, much like training an animal through consistent feedback. Through repeated exposure to this component, children develop several key understandings in developmentally appropriate language: (1) AI learns by finding patterns in examples, (2) AI uses these patterns to make decisions, (3) AI improves when mistakes are corrected, and (4) AI learning is similar to training, not thinking.

This component connects the internal learning processes of the AI Body, AI Food, and AI Brain and serves as the bridge between children's understanding of the AI-Play structure and the real AI systems they encounter in the world. Once children grasp that AI has parts (AI Body), that it depends on examples provided by people (AI Food), and that it improves by forming patterns and using them to make decisions (AI Brain – Patterns and AI Brain – Decision), they are prepared to recognize that all AI applications operate through this same structure. In every application—whether image recognition, speech interaction, text generation, or recommendation—the visible behavior of the system is the result of learning that previously occurred inside the AI Brain – Patterns phase and is now being applied through the AI Brain – Decision phase. The AI Body receives input, the AI Brain applies learned patterns, and an output is produced. When mistakes occur, new examples can be provided, returning the system to the learning phase where patterns are reshaped. For older learners, this connection becomes more explicit through conceptual language that describes what is happening inside the learning brain. Students are introduced to ideas such as machine learning, supervised, unsupervised, and reinforcement learning as different ways the AI Brain forms patterns from examples. They learn the distinction between training (AI Brain – Patterns, where learning occurs) and inference (AI Brain – Decision, where learned patterns are used). Concepts such as feedback loops, generalization versus memorization, overfitting, hallucination, explainability, confidence versus accuracy, model scope and limitations, human-in-the-loop, and ethical trade-offs help learners understand why AI behaves the way it does. These conceptual ideas are then mapped onto recognizable AI application areas such as computer vision, speech recognition, natural language processing and large language models, generative AI, recommendation systems, and multimodal AI. Through this connection, learners understand that what AI does in the world is a direct result of how learning occurred inside the AI Brain, guided by the examples provided through AI Food and the inputs received through the AI Body, all framed by human responsibility and ethics.

Implementation and Evaluation

The AI-Play framework was implemented through a series of Hour of Code lessons designed to translate the conceptual components of the framework into hands-on, play-based learning experiences for children and families. While many of these lessons were fully unplugged, several activities intentionally incorporated limited, guided screen interaction to demonstrate how the same concepts appear in real AI tools. The lessons avoided technical coding and instead emphasized experiential interaction aligned with the AI-Play components. Activities included computer vision simulations, neural network role-play, Makey Makey circuits, robotics with KIBO, robot "language" activities, game design tasks, computational thinking stories, data science sorting games, children's songs, unplugged coding challenges, and selected screen-based demonstrations. Each activity was intentionally structured to connect to AI Body, AI Food, AI Brain, and the Pre/Post-AI ethical lens, allowing children to experience AI concepts through movement, play, observation, and guided reflection rather than abstraction.

The lessons were implemented during a public Hour of Code family event. A total of 120 participants took part, including 70 children and 50 parents. Participation in the activities was open, but feedback collection was voluntary. From this group, 45 children and 18 parents consented to provide evaluative feedback. Children completed a brief reflection on the back of their activity sheet by circling one of four emoji faces to indicate how they felt about the activities. Parents completed a six-question survey focused on their child's engagement, understanding, and observable learning. Results from the child reflections indicated very high engagement. Approximately 84% of children selected the most positive emoji, 13% selected a positive emoji, and only 3% selected a neutral response, with no negative responses recorded. Parent survey responses similarly reflected strong perceived learning outcomes. Eighty-nine percent of parents reported that their child appeared highly engaged throughout the activities, 83% indicated that their child demonstrated some understanding that AI is human-made and learns from examples, and 78% reported that their child participated in discussions about fairness, mistakes, or responsibility during or after the activities. Additionally, 94% of parents expressed interest in seeing similar AI learning experiences offered again. These results suggest that the AI-Play framework successfully supported both engagement and meaningful conceptual understanding in an informal, family-centered learning context.

Conclusion

As AI becomes part of children's everyday lives, early education must help shape how young learners understand it. This paper addressed the gap between AI literacy expectations and the lack of developmentally appropriate approaches for early childhood by introducing the AI-Play framework. By translating core AI ideas into playful, experiential learning through AI Body, AI Food, AI Brain, and an ethics and agency lens, AI-Play enables educators and families to teach AI concepts without technical abstraction. Expert feedback and implementation during a family Hour of Code event demonstrated that the framework is engaging, usable, and accessible. AI-Play offers a practical bridge between AI literacy standards and early childhood pedagogy, supporting children in developing accurate, ethical, and age-appropriate understandings of AI from the earliest years. The workshops can be access using: k12datascience.org

Limitations

The implementation was conducted during a single family-centered Hour of Code event, which limits the generalizability of the findings across diverse classroom settings, age groups, and cultural contexts. Data were primarily based on parent surveys and child reflection sheets, which capture perceptions of engagement and understanding but do not provide long-term measures of learning outcomes or conceptual retention. Additionally, the activities were implemented in an informal learning environment rather than within a structured early childhood curriculum, and the study did not examine how teachers with varying levels of experience might integrate AI-Play into regular classroom practice.

Future Work

Future work will involve classroom-based implementations across Pre-K through early elementary settings to examine how AI-Play functions within daily instruction.

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References

[1] S. A. Malallah, "Developing computational thinking best practices for early childhood education in Kuwait and United States," Kansas State University, 2022.

[2] "Technology in Education: A Tool on Whose Terms?," UNESCO, 2023. [Online]. Available: https://gem-report-2023.unesco.org/technology-in-education/

[3] D. Long and B. Magerko, "What is AI literacy? Competencies and design considerations," in *Proceedings of the 2020 CHI conference on human factors in computing systems*, 2020, pp. 1-16.

[4] K. Mills *et al.*, "AI Literacy: A Framework to Understand, Evaluate, and Use Emerging Technology," *Digital Promise,* 2024.

[5] S. Malallah, L. Shamir, W. H. Hsu, J. L. Weese, and S. Alfailakawi, "Computational Thinking Pedagogical+ Framework for Early Childhood Education," in *2023 ASEE Annual Conference & Exposition*, 2023.

[6] M. U. Bers, L. Flannery, E. R. Kazakoff, and A. Sullivan, "Computational thinking and tinkering: Exploration of an early childhood robotics curriculum," *Computers & Education,* vol. 72, pp. 145-157, 2014.

[7] Tamara J. Moore, "The Integration of Computational Thinking in Early Childhood and Elementary Education," ed: Committee on Enhancing Science and Engineering in Prekindergarten through Fifth Grade, 2020.

[8] M. U. Bers, "The TangibleK robotics program: Applied computational thinking for young children," *Early Childhood Research & Practice,* vol. 12, no. 2, p. n2, 2010.

[9] J. Su and W. Yang, "A Systematic Review of Integrating Computational Thinking in Early Childhood Education," *Computers and Education Open,* p. 100122, 2023.

[10] S. Malallah, J. Weese, L. Shamer, and W. Hsu, "Data Science (Dataying) for Early Childhood," presented at the ASEE Annual Conference, 2023.

[11] S. Malallah, J. Weese, and K. Alsalmi, "The "besTech" Technology Practice Framework for Early Childhood Education," presented at the ASEE Annual Conference, 2023.

[12] S. Malallah *et al.*, "Developing an instrument for assessing self-efficacy confidence in data science," in *2024 ASEE Annual Conference & Exposition*, 2024.

[13] S. Malallah, j. osiobe, and L. Shamer, "Designing a Virtual World Experience to Foster Computational Thinking in Young Learners: An Hour of Code Initiative," presented at the ASEE Annual Conference, 2025.

[14] S. Malallah, j. osiobe, and L. Shamer, "Developing a Virtual Worlds Framework for Early Childhood," presented at the ASEE Annual Conference, 2025.

[15] L. Mannila, "Co-designing AI literacy for K-12 education," in *Proceedings of the 19th WiPSCE Conference on Primary and Secondary Computing Education Research*, 2024, pp. 1-3.

[16] J. Wang, R. Xiao, and Y.-J. Tseng, "Generating AI Literacy MCQs: A Multi-Agent LLM Approach," in *Proceedings of the 56th ACM Technical Symposium on Computer Science Education V. 2*, 2025, pp. 1651-1652.

[17] J. Robertson, S. Abaci, K. Farrell, and J. Kanwal, "Teaching Responsible AI Literacy in Schools: Perspectives from academics and teachers," in *Proceedings of the 2025 Conference on UK and Ireland Computing Education Research*, 2025, pp. 1-3.

[18] J. Renzella, N. Banks, and A. Vassar, "Building Global AI Literacy: Preparing Teachers for the Future of AI-Driven Classrooms," in *Proceedings of the 56th ACM Technical Symposium on Computer Science Education V. 2*, 2025, pp. 1727-1727.

[19] D. Long, J. Roberts, B. Magerko, K. Holstein, D. DiPaola, and F. Martin, "Ai literacy: Finding common threads between education, design, policy, and explainability," in *Extended abstracts of the 2023 CHI conference on human factors in computing systems*, 2023, pp. 1-6.

[20] M. L. Whyte, "Middle School Literacy Teachers' Perceptions of Their Self-Efficacy to Teach Reading Standards," 2017.

[21] K. C. R. Kathala and S. Palakurthi, "AI Literacy Framework and Strategies for Implementation in Developing Nations," in *Proceedings of the 2024 the 16th International Conference on Education Technology and Computers*, 2024, pp. 418-422.

[22] S. Xie, J. Solyst, A. Ogan, and J. Hammer, "Booklet-based design fiction to support AI literacy," in *Proceedings of the 54th ACM Technical Symposium on Computer Science Education V. 2*, 2022, pp. 1302-1302.

[23] C. Gardner-McCune, D. Touretzky, B. Cox, C. Dungan, and D. O'Grady-Cunnif, "Organizing State-Level Efforts for K-12 AI Education," 2023.

[24] S. A. Addo, "Are you ready to teach AI in schools? Teachers' perspectives of teaching AI in K-12 settings," in *Proceedings of the 2023 Conference on United Kingdom & Ireland Computing Education Research*, 2023, pp. 1-1.

[25] C. Gardner-McCune, D. Touretzky, F. Martin, and D. Seehorn, "AI for K-12: Making room for AI in K-12 CS curricula," in *Proceedings of the 50th ACM Technical Symposium on Computer Science Education*, 2019, pp. 1244-1244.

[26] W. Faisal, A. T. Wasi, D. Sharma, M. A. Anik, T. H. Rafi, and D.-K. Chae, "Knowledge Explorer: An Agentic AI Framework for Interactive, Personalized and Multilingual Learning Experience," in *Companion Publication of the 2025 Conference on Computer-Supported Cooperative Work and Social Computing*, 2025, pp. 520-524.

[27] K. Quille, B. A. Becker, and L. Vidal-Meliá, "The European commission and AI: Guidelines, acts and plans impacting the teaching of AI and teaching with AI," in *Proceedings of the 54th ACM Technical Symposium on Computer Science Education V. 2*, 2022, pp. 1410-1410.

[28] H. Xie, "Patterns between interactive intentions and information-seeking strategies," *Information processing and Management,* vol. 38, no. 1, pp. 55-77, 2002.

[29] E. Mabberi, "Developing Young Children Artificial Intelligence Literacy through Community-Based Approaches," in *Proceedings of the ACM Global on Computing Education Conference 2025 Vol 2*, 2025, pp. 419-419.

[30] C. Gardner-Mccune and D. Touretzky, "How States are Preparing Their Students for the Fourth Industrial Revolution," in *Proceedings of the 54th ACM Technical Symposium on Computer Science Education V. 2*, 2022, pp. 1271-1271.

[31] J. Vandenberg, R. Torbey, C. X. Zhang, B. Mott, K. Bailey, and J. Wilson, "Conceptualizing the Support and Learning of K-2 Educators around Artificial Intelligence in Language Arts," in *Proceedings of the 56th ACM Technical Symposium on Computer Science Education V. 2*, 2025, pp. 1647-1648.

[32] V. Olari *et al.*, "Introduction of artificial intelligence literacy and data literacy in computer science teacher education," in *Proceedings of the 23rd Koli Calling International Conference on Computing Education Research*, 2023, pp. 1-2.

[33] R. Landesman, M. Tare, R. A. Divanji, J. Rubin, and A. Jamalian, "Designing AI for Children's Well-Being," in *Proceedings of the 24th Interaction Design and Children*, 2025, pp. 1239-1241.

[34] G. K. Wong, X. Ma, and J. Huen, "When schools meet artificial intelligence in Hong Kong," *ACM Inroads,* vol. 10, no. 4, pp. 43-46, 2019.

[35] K. Tang, Eugene, T. Song, Z. Zhu, J. Li, and Y.-C. Lee, "AI Literacy Education for Older Adults: Motivations, Challenges and Preferences," in *Proceedings of the Extended Abstracts of the CHI Conference on Human Factors in Computing Systems*, 2025, pp. 1-15.

[36] M. Kasinidou, Â. Videira dos Santos, A. Silva, S. Kleanthous, and J. Otterbacher, "'AI Training Should Be for Everyone': Informal training on AI," in *Proceedings of the 30th*

ACM Conference on Innovation and Technology in Computer Science Education V. 2, 2025, pp. 778-778.
[37] AAAI and CSTA, "Five Big Ideas in AI," ed.
[38] "Official CSTA K–12 Standards," ed.
[39] "UNESCO AI & Education Frameworks," ed.
[40] D. Gašević, G. Siemens, and S. Sadiq, "Empowering learners for the age of artificial intelligence," vol. 4, ed: Elsevier, 2023, p. 100130.
[41] "TeachAI K-12 AI Literacy Projects & Resources," ed.
[42] "RITEC Framework by UNICEF & LEGO," ed.