Co-Designing Unplugged Learning Activities with K-2 Teachers for Early AI Literacy Education

Jessica Vandenberg[1], Keisha Bailey[2], Claire Aguiar[1], Cecilia Xuning Zhang[2], Danny Schmidt[3], Treshonda Rutledge[2], Bradford Mott[1], Joseph P. Wilson[2]

[1]North Carolina State University, Raleigh, NC, USA
[2]American Institutes for Research, Arlington, VA, USA
[3]Partner to Improve, Franklin, TN, USA
jvanden2@ncsu.edu, kbailey@air.org, cmaguiar@ncsu.edu, xzhang@air.org,
danny.schmidt@partnertoimprove.com, trutledge@air.org, bwmott@ncsu.edu, jwilson@air.org

Abstract

Introducing AI concepts in the earliest years of schooling can help children make sense of intelligent technologies, yet few resources exist for K–2 classrooms. This paper presents the design and outcomes of a professional development (PD) program supporting K–2 teachers as they explored AI literacy and co-designed unplugged classroom activities. Grounded in AI4K12's Five Big Ideas in AI framework, the PD combined hands-on learning, collaborative design, and micro-teaching opportunities. Guiding activities included *Train the AI* (pattern recognition), *What Happens Next?* (consequences of AI use), *Who Did the Robot Hear?* (data diversity), and *Teach the Robot* (model training). Educators then created screen-free, English Language Arts-aligned activities using storytelling, sorting, and embodied play to introduce AI topics such as machine learning and fairness in age-appropriate ways. The PD emphasized integrating AI into existing K–2 literacy routines, lowering implementation barriers while supporting vocabulary development, reasoning, and empathy. Teacher reflections revealed growing confidence in adapting AI topics for young learners and highlighted the value of peer collaboration, clear language, and tactile materials.

Introduction

Just as early literacy and numeracy prepare children for lifelong learning, early exposure to AI concepts can lay the groundwork for thoughtful, ethical engagement with technology. As these technologies continue to evolve, early education has a critical role to play in cultivating foundational AI literacy (Long and Magerko 2020; Lee and Kwon 2024; Solichah and Shofiah 2024; Vandenberg et al. 2025). Although research and development in K–12 AI education has primarily focused on middle and high school learners, significantly less attention has been given to how young children can begin reasoning about AI systems in age-appropriate ways (Druga and Ko 2021; Ottenbreit-Leftwich et al. 2023; Simbeck and Kalff 2024).

This paper presents the design and early outcomes of a professional development (PD) program for K–2 educators centered on AI literacy implemented within the *AI by 8* project, which aims to promote AI literacy among K–2 learners. Drawing on the widely adopted AI4K12 initiative's *Five Big Ideas in AI* framework—*Perception, Representation & Reasoning, Learning, Natural Interaction,* and *Societal Impact*—this work supports teachers in developing their own understanding of AI and co-designing unplugged activities tailored for young learners (Touretzky et al. 2019).

Unplugged activities, which provide screen-free opportunities for students to explore computational and ethical reasoning through play and interaction (Bell and Vahrenhold 2018; Huang and Looi 2021; Dai 2025; Sampanis 2025; Druga and Ko 2021), are especially well-suited for early elementary classrooms (Dai 2025). However, few existing resources provide guided, developmentally appropriate entry points into AI for this age group. To address this gap, we developed a multi-day professional learning experience to support teacher learning and collaborative resource design, focused in particular on the Big Ideas of *Learning* and *Societal Impact*. These two ideas connect closely to young children's emerging understandings of patterns, fairness, and decision-making. A key outcome of this work is a set of co-designed, developmentally appropriate unplugged activities for early AI literacy, aligned with English Language Arts (ELA) practices and the AI4K12 framework.

Related Work

AI Literacy in Early Elementary Education

Much of the recent research in K–12 AI education has focused on middle and high school learners, resulting in a growing recognition that foundational ideas can and should be introduced in the earliest years of schooling (Ottenbreit-Leftwich et al. 2023; Simbeck and Kalff 2024; Solichah and Shofiah 2024). Early exposure to AI concepts can lay the groundwork for ethical, thoughtful engagement with technology and help children develop critical reasoning skills alongside literacy and numeracy (Su and Zhong 2022; Vandenberg et al. 2025; Yeter, Yang, and Sturgess 2024).

Empirical studies show that introducing AI at the primary level can support learning, reasoning, creativity, and problem solving (Gupta et al. 2024; Su and Zhong 2022). Yeter's (2024) global mapping of AI literacy research and policy highlights early childhood education as a critical but underdeveloped domain, echoing prior work in early childhood

computing (Bers 2020; Sullivan and Bers 2019) that calls for frameworks integrating ethical awareness and inclusivity from the outset.

Co-Design with Educators

Co-design approaches position educators as active partners in curriculum development, leveraging their pedagogical expertise, contextual knowledge, and understanding of students' developmental needs (Ottenbreit-Leftwich et al. 2023; Lin and Van Brummelen 2021). Previous research has demonstrated that collaborative design processes can lead to greater teacher ownership of materials, higher implementation fidelity, and richer integration with local standards and practices (Penuel and Gallagher 2017; Voogt et al. 2015). The CELaRAI project (Cai et al. 2025) emphasizes culturally responsive AI-supported literacy tools, which mirrors the current study's emphasis on collaborative resource design for K-2 classrooms.

Moreover, our work is organized around key principles of a Research-Practice Partnership (RPP): it is designed as a long-term collaboration purposefully organized to bring together members with a diversity of expertise who will all work toward the improvement of equitable AI education (Farrell, Wentworth, and Nayfack 2021). Importantly, RPPs shift the historical power relations between researchers and educators, intentionally creating a community where all members have agency over the research endeavors.

Frameworks, Policies, and Integration

The *Five Big Ideas in AI* framework (Touretzky et al. 2019) and curricula such as DAILy (Zhang et al. 2023) illustrate scalable ways to introduce AI concepts. More recent work emphasizes interdisciplinary integration across subjects while centering equity and transparency (Allen and Kendeou 2024). Policy analyses call for early AI literacy efforts that align with computational thinking and social-emotional learning goals (Wing 2006; Yim and Su 2025; Yeter, Yang, and Sturgess 2024). Our work responds by co-designing unplugged, story-based activities that provide equitable and developmentally appropriate entry points for young learners.

Assessment and Measurement of AI Literacy

Although frameworks for AI literacy are emerging (Ng et al. 2021; Allen and Kendeou 2024), reviews highlight persistent gaps in assessing younger learners (Zhou et al. 2025). Existing instruments are often designed for older students, and prior studies relying on teacher interviews highlight the need for more systematic approaches to measurement (Ottenbreit-Leftwich et al. 2023). Recent work has begun addressing these challenges by developing and validating instruments for upper elementary learners. For example, Chakraburty et al. (2025) applied Rasch modeling to examine item difficulty and construct validity in assessing students' conceptual understanding of AI, while Vandenberg and Mott (2023) explored young learners' perceptions of AI to inform instrument design grounded in children's language and reasoning. Our work contributes by embedding simple, formative assessments into early-grade activities, laying groundwork for future development of age-appropriate measures of both teacher and student learning.

Challenges and Equity Considerations

Despite progress, challenges persist in bringing AI literacy to primary education. Casal-Otero et al. (2023) identifies barriers such as the lack of structured curricula, reliance on outdated tools, and inequities tied to gender and socioeconomic status. Addressing these challenges requires low-resource instructional designs and sustained professional development to ensure inclusive participation (Bell and Vahrenhold 2018; Huang and Looi 2021).

Methods

Context and Participants

Participants were recruited through a statewide interest form distributed via social media, district listservs, and direct email invitations to elementary educators in a southeastern state in the United States. The recruitment process aimed to ensure broad representation across grade levels (K–2) and geographic regions, with an emphasis on rural districts. Applicants provided information about their teaching role, district, and reasons for participating. From this pool, eight educators were selected to represent diverse instructional roles, including classroom teachers, literacy specialists, and technology coaches—bringing a range of perspectives to the co-design process. The professional development took place in July 2025 and included kindergarten through second grade classroom teachers. Most of the participants had limited prior exposure to AI beyond informal experiences with digital assistants or classroom tools. Their interest in participating reflected both curiosity about AI and a desire to better prepare their students for a rapidly changing world.

PD Structure

The PD was designed as a multi-day, collaborative learning experience that combined structured sessions focused on supporting teachers' understanding of foundational AI concepts with teacher-driven design activities (Figure 1). Teachers engaged in multiple reflection activities as well as a micro-teaching activity. Informed by adult learning principles and co-design practices, the PD introduced participants to all Five Big Ideas in AI (Touretzky et al. 2019), with greater emphasis on the Big Ideas of *Learning* (how AI systems identify patterns from data) and *Societal Impact* (how AI affects people's lives, including issues of bias, fairness, and access) based on initial teacher preference.

Moreover, to ensure ease of adoption into classrooms, the research team intentionally prioritized English Language Arts (ELA) standards, using AI as a purposeful context for reading, writing, speaking, and listening. Rather than positioning AI as an add-on or separate subject, each activity was designed to support core ELA skills, such as forming and justifying opinions, understanding categories and relationships between words, and participating in collaborative conversations. By embedding AI concepts within familiar instructional routines like story-based discussions, sorting

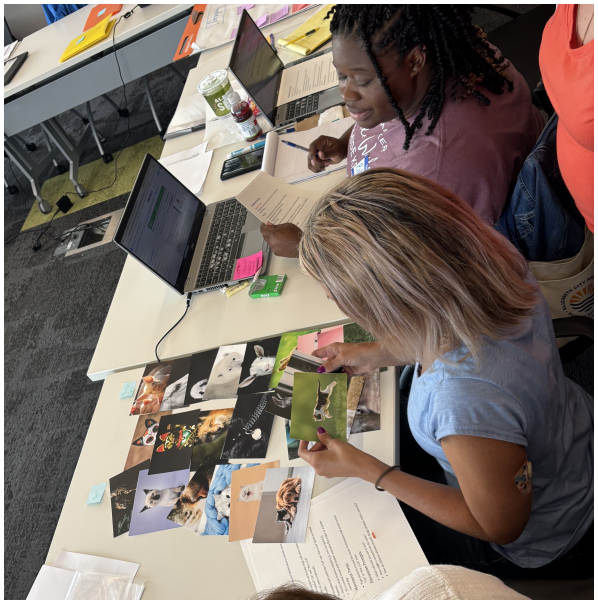

Figure 1: Teachers Co-designing AI Learning Activities.

tasks, and physical activities, the activities enables educators to meet key ELA benchmarks while introducing foundational ideas about how AI systems learn and impact the world. This integration lowers the barrier to entry for K–2 educators, who often have limited time or flexibility for standalone AI instruction, and positions AI literacy as a natural extension of early childhood inquiry and communication.

In preparation for the PD, the research team curated a set of learning activities that provided essential background information on specific AI concepts, prompts aimed at encouraging teachers to reflect on their understanding and that of their students, and discussions around how to design activities to be age-appropriate. Table 1 illustrates a sample of the activities the teachers engaged in and their alignment with both AI concepts and ELA standards.

Co-Design Process

The PD's co-design model drew on research–practice partnership principles, positioning educators as curriculum co-developers who leveraged their knowledge of students' developmental needs and classroom realities. Working in pairs or triads, they brainstormed, prototyped, and iterated on unplugged AI learning activities grounded in storytelling, logic, embodied learning, and discussion. Over the course of the PD, participants also raised questions about equity, play, and inquiry—key areas of alignment between AI ethics and early childhood pedagogy (Ottenbreit-Leftwich et al. 2023).

By incorporating co-design in the professional learning, we produced a reusable set of unplugged, literacy-aligned AI activities, each adaptable to different grade levels and classroom contexts. The resources are designed for minimal material implementation, lowering barriers for rural and resource-constrained schools, and are accompanied by teacher-facing guides to support adoption beyond the PD cohort (Hartman et al. 2023; Oh et al. 2024).

Materials and Setup

To ensure accessibility and ease of classroom integration, all of the activities were designed around commonly available classroom materials and adaptable formats. During the PD sessions, teachers received a set of printed activity cards, sorting mats, simple manipulatives (e.g., tokens, clipart icons, labels), and printable role cards. Each activity required minimal technology—relying instead on tactile, hands-on elements like laminated cards, dry-erase boards, sentence strips, and anchor chart templates.

The *Train the AI* activity uses simple image cards (e.g., pictures of cats, dogs, lions, and non-animal objects) printed on cardstock, which teachers can replicate with magazine cutouts, stickers, or clipart. The *What Happens Next?* activity involves scenario cards describing fictional students and their needs, which can be adapted to align with classroom routines like morning meetings or social-emotional learning discussions. For *Who Did the Robot Hear?*, teachers use labeled voice type cards, which are acted out, eliminating the need for audio equipment while fostering speaking and listening practice. The *Teach the Robot* activity uses tokens or paper icons that students sort and label, and can be recreated with typical classroom materials. Each activity was adapted from existing unplugged activities (Lindner and Seegerer n.d.) and modified specifically for K–2 literacy integration. Adjustments included using simpler materials, embedding storytelling and vocabulary-building components, and aligning the activity with early ELA standards.

For each activity, the research team and teachers discussed modifications to categories, visuals, or vocabulary to fit local curriculum or student interests. These modifications were intended to support widespread adaptation across classrooms with limited prep time or supply budgets, while reinforcing connections to literacy instruction through labeling, describing, sorting, and storytelling.

Data Collection and Analysis Approach

Teacher feedback from digitally recorded transcripts was analyzed using a thematic analysis approach (Clarke and Braun 2014). Two members of the research team independently reviewed transcripts from PD discussions, written reflections, and micro-teaching debrief notes. Each coder generated initial codes inductively, focusing on recurring patterns in teacher perceptions, adaptations, and questions. The coders then met to compare and consolidate codes into broader themes, resolving differences through discussion. This process resulted in two primary thematic areas, *Conceptualizing Learning in AI* and *Societal Relevance of AI*, which structure the presentation of teacher feedback below.

Results

Resulting Resources

The primary resources resulting from this work is a set of teacher-developed, unplugged AI literacy activities designed for K–2 students. These activities were co-designed during the three-day professional learning summit. The summit combined educator learning experiences with structured design opportunities, culminating in a series of draft lesson

plans intended to support early AI literacy in developmentally appropriate ways.

The key types of resources co-developed during the summit include the following:

- **Unplugged learning activities** (e.g., image sorting games, fairness dilemmas, pattern recognition tasks)
- **Story-based discussion prompts** aligned with AI ethics (e.g., "Who gets the robot helper?")
- **Teacher reference sheets** for each Big Idea, with K–2 examples
- **Micro-teaching artifacts** produced by teachers during the summit

The PD agenda intentionally scaffolded the development of these resources. On Day 1, participants engaged in guided learning experiences around the Five Big Ideas, with extended focus on *Learning* and *Societal Impact*. These experiences included hands-on simulations (e.g., "Train the AI" sorting task) and structured discussions. On Day 2, teachers transitioned into lesson design mode through the "Lesson Development Dream and Design" sessions and later prototyped their activities during "Micro-teaching" presentations. Teacher-generated resources were refined collaboratively and captured for future implementation.

The design of these activities was guided by several interrelated goals. First, they were developed to be accessible to early elementary educators, many of whom do not have prior experience with AI or computer science. This meant using familiar instructional practices (e.g., sorting, storytelling, oral discussion) and common classroom materials (e.g., cardstock, image cards, pocket charts). Second, the activities were intentionally developmentally appropriate, emphasizing concrete, observable features of AI behavior through play and pattern recognition rather than abstract definitions. Third, they reflect an inquiry-based approach, encouraging students to ask questions, make predictions, explain their reasoning, and reflect on how AI systems can impact people differently. Finally, the activities were aligned with English Language Arts standards (with AI concepts providing the context rather than the instructional objective), allowing teachers to integrate AI literacy into their everyday literacy instruction.

All co-designed activities, teacher reference sheets, and micro-teaching exemplars will be made available as open educational resources (OER). Each resource includes printable materials, guidance on adapting for diverse literacy levels, and clear alignment to English Language Arts standards. By emphasizing ease of preparation and flexible adaptation, the resource set is positioned for broad use in K–2 classrooms, including those with limited access to technology.

AI Concepts Addressed

The activity resources address multiple concepts aligned with the Five Big Ideas in AI framework (Touretzky et al. 2019), with particular emphasis on the Big Ideas of *Learning* and *Societal Impact*.

- **Learning**: Many activities focus on how AI systems "learn" from data, using simplified analogies such as showing an AI multiple examples of animals or snacks and then asking it to classify a new item. These activities help students grasp pattern recognition and introduce the idea that AI can make mistakes if its training data is incomplete or biased.
- **Societal Impact**: Teachers developed scenarios and discussion-based prompts to help students explore who benefits or is left out when AI is used in everyday life. For example, one lesson has students consider who gets chosen for a prize by a robot that only selects people with perfect attendance, prompting conversations about fairness and access.
- **Perception and Natural Interaction**: Several activities indirectly touch on how AI perceives and interacts with the world (e.g., through simulations of voice assistants or robot vision). Teachers used classroom examples like smart speakers and digital reading tools to connect these ideas to students' lived experiences.
- **Representation and Reasoning**: While addressed more briefly, this concept was incorporated into activities where students traced how a system might make a decision based on remembered information or logical steps (e.g., finding the fastest route in a classroom map).

Overall, the learning activities are designed to support students in recognizing AI systems around them, asking critical questions, and engaging in early ethical reasoning. The lessons support age-appropriate goals in computational thinking and digital citizenship (Simbeck and Kalff 2024; Solichah and Shofiah 2024).

Teacher Feedback Themes

Teacher reflections during and after the professional learning summit provided insight into both the design process and the classroom feasibility of the learning activities. Their feedback highlighted opportunities as well as challenges in bringing early AI literacy into K–2 classrooms. The following themes capture key areas of teacher experience, each illustrated with representative comments.

Conceptualizing Learning in AI. During the professional development sessions, teachers engaged deeply with the machine learning activities, surfacing both enthusiasm and pedagogical insights. A recurring theme across discussions was the need to clarify how abstract AI concepts, like learning from data or recognizing patterns, could be made developmentally appropriate for early learners. Teachers collaboratively refined the kid-friendly definition of machine learning, suggesting simpler terms like "photos" or "ideas" in place of "things," and flagging the word "patterns" as potentially unfamiliar for K–2 students. These conversations highlighted the importance of precise, accessible language when introducing new concepts to young children.

The teachers saw immediate and natural connections between the machine learning tasks and core literacy practices. Activities like *Train the AI*, which invited students to determine whether images represented a "cat" or "not a cat," were recognized as opportunities for students to practice classification, oral reasoning, and descriptive vocabulary. Educators noted that these activities promoted rich conversation

Activity and AI Concepts	ELA Standard(s)	ELA Integration Description
Train the AI (Cat vs. Not a Cat) *AI Concepts:* Learning (pattern recognition, supervised learning, generalization, bias in training data)	K — Explore word relationships by sorting (with support) 1 — Participate in conversations; ask/answer, follow discussion rules 1 — Write opinion pieces with reason and closure	Students sort images and use descriptive vocabulary to categorize items. They justify predictions about what the "AI" will decide, promoting oral language development and justifying their opinions.
What Happens Next? (Fairness in AI decisions) *AI Concepts:* Societal Impact (consequences of AI use, bias, access, fairness)	K — Engage in discussions, listening, turn-taking 1 — Describe story elements (characters, events) with detail 2 — Use experiences/sources to write responses (basic research)	Students analyze short character scenarios and predict AI-driven outcomes. They discuss fairness, express opinions, and reflect on how AI decisions can affect people differently.
Who Did the Robot Hear? (Voice variety) *AI Concepts:* Societal Impact + Perception (data diversity, inclusivity, accessibility)	K — Link words to real-life use (with help) K — Express opinion via drawing/dictation with reason 2 — Have structured discussions on grade-level topics	Students explore and describe diverse types of voices. Through role-playing and discussion, they reflect on which voices are heard or misunderstood by AI, encouraging empathy and critical thinking.
Teach the Robot (Student as data labeler) *AI Concepts:* Learning (model training, classifying examples)	K — Describe familiar things and add details (with prompting) 1 — Sort words into categories to understand their meaning 2 — Use experiences/sources to write responses (basic research)	Students act as AI trainers by designing labeled data sets. They explain their reasoning aloud and discuss instructional steps, supporting vocabulary development.

Table 1: Alignment of AI Literacy Activities in the PD with K–2 English Language Arts Standards.

and could easily be adapted to small-group reading sessions or center rotations using familiar classroom materials such as stickers, cut-outs, or manipulatives. The tactile and movement-based design of the activities was especially well received, with teachers emphasizing that hands-on engagement is essential for maintaining attention and supporting understanding in early elementary settings.

Teachers expressed curiosity about introducing more complex AI models, including reinforcement learning. They brainstormed simple reward systems to mirror AI feedback loops using familiar structures like points, stickers, or free choice time. Participants also emphasized supporting students' language development around AI, suggesting visual aids like anchor charts and audio recordings to reinforce vocabulary. These takeaways reflect their confidence in adapting AI concepts to early learning and eagerness to integrate them into existing routines.

These teacher insights directly informed resource revisions, including the use of simplified, student-friendly vocabulary, visual aids, and the addition of optional reinforcement learning simulations. This iterative improvement process reflects our commitment to co-design, ensuring that the resources are pedagogically sound and practically usable.

Societal Relevance of AI. In exploring AI's societal impacts, teachers engaged in dialogue about fairness, bias, and how AI systems affect people differently. The session introduced real-world, age-appropriate examples—from voice recognition to algorithmic decision-making in justice and media. Teachers noted AI's dual nature, recognizing both helpful applications (e.g., robot assistants) and potential harms (e.g., reinforcing bias). Facilitators guided discussions on student- and teacher-friendly definitions of societal impact, and educators refined ways to communicate fairness, access, and consequences of biased data to young learners. Challenges included uncertainty about district requirements and where to situate AI lessons within literacy schedules, as well as navigating administrative review and gauging reactions from school leaders and parents.

A resonant idea was framing fairness as "everyone getting what they need," aligned with classroom norms and socio-emotional learning. Teachers explored concrete examples, such as why a voice assistant might respond to one voice but not another, and adapted discussions of biased sentencing software for younger audiences. Educators suggested modifying activities using relatable classroom scenarios and creating differentiated versions to match developmental levels and cultural contexts.

Hands-on group demonstrations, with teachers taking on student roles, surfaced key implementation questions—how to frame voice-based bias, which voices to include, and ensuring all students feel seen. These activities sparked rich conversations about equity, inclusion, and how children's experiences shape interactions with AI. Overall, the session empowered teachers to translate abstract ethical concerns into tangible early learning experiences grounded in fairness, empathy, and critical thinking.

Micro-teaching Lessons

During the second day of the PD, teachers collaboratively participated in a micro-teaching session where they co-designed and facilitated short K-2 ELA/literacy lessons with an infused focus on AI concepts embedded within. Each group modeled their activity for peers, received feedback, and reflected on ways to improve both the clarity of AI concepts and the alignment with literacy standards. These micro-teaching moments showcased the teachers' growing confidence and creativity in embedding AI ideas into developmentally appropriate classroom routines.

The kindergarten group focused on a lesson about the five senses, designed to compare human perception with how AI "senses" the world using tools like cameras and microphones. Students would engage in sensory-based activities and then consider how different technologies might interpret those same inputs. For example, they would discuss how a camera might "see" objects differently than a human eye, or how a voice assistant responds to sound. This lesson has strong alignment with both science and literacy standards, using descriptive language and comparison skills while introducing ideas related to data collection and perception in AI systems.

The first grade group developed a lesson centered on storytelling and story structure, using AI as a frame for collaborative creativity. Students would generate different parts of a story (such as characters, settings, or plot points) and then combine them as a class, simulating the process of an AI generating a story based on inputs. Students would be encouraged to reflect on how creative choices are shaped by available data. The lesson emphasized core ELA standards related to identifying and describing story elements while offering an introduction to how generative AI works. During feedback, peers noted the value of using more concrete input/output examples and incorporating visual aids to support understanding.

The second grade group based their lesson on "The Boy Who Cried Wolf" to explore AI alert systems and trustworthiness. Students would act as villagers responding to alerts sent by an "AI wolf detector" and used red and green cards to indicate whether they believed each alert was true or false. This highly interactive lesson promoted critical thinking about when and why we trust machines, and opened space for discussing concepts like false positives and false alarms. Teachers noted strong alignment with both second grade reading and writing standards, as students would need to justify their decisions and reflect on evidence from the story.

Throughout the micro-teaching process, teachers reflected on the importance of clear vocabulary, visual scaffolds, and interactivity. They also embraced the role of peer feedback in refining their lessons, adjusting for clarity, age-appropriateness, and instructional flow. These sessions illustrated the potential for early elementary educators, regardless of prior experience with AI, to design thoughtful, integrated, and standards-aligned learning experiences that introduce young children to the foundational ideas of artificial intelligence (Table 2).

Discussion

Implications for Early AI Literacy

This work demonstrates the feasibility and promise of introducing AI concepts to early elementary students through unplugged, literacy-first activities co-designed with K–2 educators. Grounding the PD in familiar strategies such as storytelling and embodied play helped teachers make abstract AI ideas—like learning from data or considering fairness—developmentally appropriate for young learners (Strawhacker and Bers 2015; Israel et al. 2015). These activities extended existing English Language Arts (ELA) routines rather than functioning as standalone AI lessons, lowering barriers to adoption.

Teachers' enthusiastic engagement and thoughtful adaptations highlight the value of co-design focused on developmental appropriateness and classroom realities. Educators created resources aligned with state standards that foster vocabulary, reasoning, and empathy—key practices supporting literacy and responsible technology use. This alignment suggests a scalable path for integrating AI into early elementary instruction without straining classroom time. Together, the team and teachers curated a growing list of K–2 mentor texts that introduce AI-related ideas such as pattern recognition, decision-making, and fairness, grounding emerging AI literacy lessons in stories and practices teachers already value.

An important dimension of this work is its attention to equity. By emphasizing low-floor activities using common classroom materials, the lessons are accessible across diverse contexts, including rural and under-resourced schools. This adaptability broadens participation in early AI literacy efforts.

Professional Development Design

The PD model itself which combined foundational AI concept exploration, collaborative lesson design, and peer micro-teaching, emerged as a key contribution of this work. By structuring the PD to move from concept introduction to co-design to practice teaching, participants were able to iteratively deepen their own understanding of AI while immediately applying that knowledge to classroom-ready resources.

This sequence allowed teachers to explore new content in a supportive setting, receive peer feedback on lesson prototypes, and refine activities for clarity and age-appropriateness. The approach also fostered teacher confidence, with participants reporting that they felt more prepared to introduce AI concepts to their students. Given its adaptability, this PD design could be applied to other grade bands, subject areas, or emerging technology topics, offering a replicable model for teacher professional learning.

Limitations

First, the PD was conducted with a small cohort of eight educators from rural communities in a single southeastern U.S. state. The limited sample size and geographic scope constrain the generalizability of the results. Second, all findings are based on PD activities and teacher-designed resources rather than classroom implementation. Although teachers

Grade / Lesson	Teacher Reflection (Verbatim)
Kindergarten Categorizing everyday objects	**Teacher**: "I like to use a lot of movement. So my thing would [be to] put them on popsicle sticks and give them out to each student and then tell them to categorize themselves. Yeah, so they're physically then reorganizing." **Facilitator**: "OK, what type of learning is that? Is that supervised, unsupervised or reinforcement?" **Teacher**: "It's all three. It's all three… the way we take things from the STEM approach is we give the problem, but then they have to come up with a solution. So I would tell them what the problem is… that would be the supervised. The unsupervised is giving them the creative freedom to figure out what categories they want to use and then how are they going to match up with each other… the reinforcement would be them making their own categories… and then have them break down their categories even smaller."
Grade 1 Sequencing a familiar story to model algorithms	**Teacher**: "I'd give them the story cards out of order and have them work together to put them back in order… so they're figuring out what comes first, next, last." **Facilitator**: "And how would you connect that to AI for them?" **Teacher**: "It's like telling the computer exactly what to do in the right order. If you don't give the steps in the right sequence, the computer gets it wrong… so they check and fix it, just like debugging."
Grade 2 Acting out AI decision-making	**Teacher**: "I'd have them pretend to be the computer, like they're taking in the data, and then they have to give an output." **Facilitator**: "Could you add conditions so it's more like AI decision-making?" **Teacher**: "Yes — like, 'only if it has four legs' or 'only if it's red'… so they're deciding what stays in and what goes out." **Another Participant**: "And they can see how one change in the rule changes the whole result."

Table 2: Teacher Reflections on Integrating AI Concepts into K–2 Lessons.

reflected on feasibility and alignment with existing standards, the actual effect on student engagement or learning has not been studied yet. Third, participants volunteered for the PD, which may mean they were more motivated or open to innovation than the broader K–2 educator population. Finally, due to time limitations, the PD emphasized only two of the five big AI ideas ("Learning" and "Societal Impact"), based on teacher interest. The three additional big ideas will be part of ongoing virtual learning series with teachers during the 2025-26 school year.

Future Work

Future phases will address current limitations. In the 2025–26 school year, teachers will join a virtual professional learning community (PLC) to implement co-designed lessons, reflect on instruction, and further explore the Five Big Ideas in AI. The research will examine facilitators and barriers to implementation, student engagement and learning in unplugged AI activities, changes in teacher self-efficacy, and ways to tailor PD for rural K–2 educators. We also plan to expand the resource set with unplugged activities aligned to the remaining Big Ideas. By refining and studying these approaches in authentic classrooms, we aim to build a foundation for equitable, early AI literacy in the earliest years of schooling.

Conclusion

This paper described the design and initial implementation of professional development to help K–2 teachers integrate AI literacy into their classrooms. Through a three-day summit, educators engaged with core AI concepts and co-designed unplugged, literacy-aligned activities. Teacher feedback underscored both the promise of these resources and the need for continued support in adapting them to diverse contexts.

Our work makes three contributions. First, it demonstrates the feasibility of engaging early elementary educators in co-design processes that yield practical classroom activities. Second, it provides examples of how the Five Big Ideas in AI can be translated into literacy-based lessons. Third, it highlights the value of embedding formative assessment into unplugged activities as a step toward addressing gaps in early AI literacy measurement.

This work adds to growing research on AI literacy in primary education by modeling how teacher professional development, co-design, and classroom testing can generate equitable, developmentally appropriate resources. As AI becomes increasingly present in children's lives, such efforts are vital to ensuring even the youngest learners can begin to understand and question the technologies shaping their world.

Acknowledgements

This research was supported by the National Science Foundation (NSF) under Grants DRL-2434580 and DRL-2434579. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the NSF.

References

Allen, L. K.; and Kendeou, P. 2024. ED-AI Lit: An interdisciplinary framework for AI literacy in education. *Journal of Educational Psychology*.

Bell, T.; and Vahrenhold, J. 2018. CS unplugged—how is it used, and does it work? In *Adventures between lower bounds and higher altitudes: Essays dedicated to Juraj Hromkovič on the occasion of his 60th birthday*, 497–521. Springer.

Bers, M. U. 2020. *Coding as a playground: Programming and computational thinking in the early childhood classroom*. Routledge.

Cai, Z. J.; Xing, G. Y.; Yamamoto, Y.; and Wang, X. C. 2025. From Piaget to posthumanism: Critical review of conceptualization of AI in early childhood education. *AI, Brain and Child*, 1(1): 1–17.

Casal-Otero, L.; Catala, A.; Fernández-Morante, C.; Taboada, M.; Cebreiro, B.; and Barro, S. 2023. AI literacy in K-12: A systematic literature review. *International Journal of STEM Education*, 10(1): 29.

Chakraburty, S.; Glazewski, K. D.; Hmelo-Silver, C. E.; Svetina Valdivia, D.; Ottenbreit-Leftwich, A.; Mott, B.; and Lester, J. 2025. Measuring upper-elementary students' understanding of AI concepts–a Rasch model analysis. *Information and Learning Sciences*.

Clarke, V.; and Braun, V. 2014. Thematic analysis. In *Encyclopedia of Critical Psychology*, 1947–1952. Springer.

Dai, Y. 2025. Integrating unplugged and plugged activities for holistic AI education: An embodied constructionist pedagogical approach. *Education and Information Technologies*, 30(5): 6741–6764.

Druga, S.; and Ko, A. J. 2021. How do children's perceptions of machine intelligence change when training and coding smart programs? In *Proceedings of the 20th Annual ACM Interaction Design and Children Conference*, 49–61.

Farrell, C. C.; Wentworth, L.; and Nayfack, M. 2021. What are the conditions under which research-practice partnerships succeed? *Phi Delta Kappan*, 102(7): 38–41.

Gupta, A.; Lee, S.; Mott, B.; Chakraburty, S.; Glazewski, K.; Ottenbreit-Leftwich, A.; Scribner, A.; Hmelo-Silver, C. E.; and Lester, J. 2024. Supporting upper elementary students in learning AI concepts with story-driven game-based learning. In *Proceedings of the AAAI Conference on Artificial Intelligence*, volume 38, 23092–23100.

Hartman, S. L.; Johnson, J.; Showalter, D.; Eppley, K.; and Klein, B. 2023. Why Rural Matters 2023: Centering equity and opportunity: A discussion with the research team. *The Rural Educator*, 44(4): 69–71.

Huang, W.; and Looi, C.-K. 2021. A critical review of literature on "unplugged" pedagogies in K-12 computer science and computational thinking education. *Computer Science Education*, 31(1): 83–111.

Israel, M.; Wherfel, Q. M.; Pearson, J.; Shehab, S.; and Tapia, T. 2015. Empowering K–12 students with disabilities to learn computational thinking and computer programming. *TEACHING Exceptional Children*, 48(1): 45–53.

Lee, S. J.; and Kwon, K. 2024. A systematic review of AI education in K-12 classrooms from 2018 to 2023: Topics, strategies, and learning outcomes. *Computers and Education: Artificial Intelligence*, 6: 100211.

Lin, P.; and Van Brummelen, J. 2021. Engaging teachers to co-design integrated AI curriculum for K-12 classrooms. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*, 1–12.

Lindner, A.; and Seegerer, S. n.d. AI Unplugged: Unplugging artificial intelligence-activities and teaching material on artificial intelligence. http://www.aiunplugged.org.

Long, D.; and Magerko, B. 2020. What is AI literacy? Competencies and design considerations. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*, 1–16.

Ng, D. T. K.; Leung, J. K. L.; Chu, S. K. W.; and Qiao, M. S. 2021. Conceptualizing AI literacy: An exploratory review. *Computers and Education: Artificial Intelligence*, 2: 100041.

Oh, D. D.; Rich, K. M.; Bosch-Wilson, K. L.; and Cunningham, H. L. 2024. Motivating and increasing the relevance of elementary computer science in rural communities: Exploring elementary teacher perspectives in Idaho. In *Proceedings of the 55th ACM Technical Symposium on Computer Science Education V. 2*, 1768–1769.

Ottenbreit-Leftwich, A.; Glazewski, K.; Jeon, M.; Jantaraweragul, K.; Hmelo-Silver, C. E.; Scribner, A.; Lee, S.; Mott, B.; and Lester, J. 2023. Lessons learned for AI education with elementary students and teachers. *International Journal of Artificial Intelligence in Education*, 33(2): 267–289.

Penuel, W. R.; and Gallagher, D. J. 2017. *Creating Research-Practice Partnerships in Education.* ERIC.

Sampanis, N. 2025. Innovative tangible interactive games for enhancing artificial intelligence knowledge and literacy in elementary education: A pedagogical framework. *arXiv preprint arXiv:2506.00651*.

Simbeck, K.; and Kalff, Y. 2024. Understanding how computers learn: AI literacy for elementary school learners. In *Proceedings of Mensch und Computer 2024*, 375–380.

Solichah, N.; and Shofiah, N. 2024. Artificial intelligence (AI) literacy in early childhood education: A scoping review. *Psikologika: Jurnal Pemikiran dan Penelitian Psikologi*, 29(2): 173–190.

Strawhacker, A.; and Bers, M. U. 2015. "I want my robot to look for food": Comparing kindergartners' programming comprehension using tangible, graphic, and hybrid user interfaces. In *International Journal of Technology and Design Education*, volume 25, 293–319.

Su, J.; and Zhong, Y. 2022. Artificial Intelligence (AI) in early childhood education: Curriculum design and future directions. *Computers and Education: Artificial Intelligence*, 3: 100072.

Sullivan, A.; and Bers, M. U. 2019. Computer science education in early childhood: The case of ScratchJr. *Journal of Information Technology Education. Innovations in Practice*, 18: 113.

Touretzky, D.; Gardner-McCune, C.; Martin, F.; and Seehorn, D. 2019. Envisioning AI for K-12: What should every child know about AI? In *Proceedings of the AAAI Conference on Artificial Intelligence*, volume 33, 9795–9799.

Vandenberg, J.; and Mott, B. 2023. "AI teaches itself": Exploring young learners' perspectives on Artificial Intelligence for instrument development. In *Proceedings of the 2023 Conference on Innovation and Technology in Computer Science Education V. 1*, 485–490.

Vandenberg, J.; Torbey, R.; Zhang, C. X.; Mott, B.; Bailey, K.; and Wilson, J. 2025. 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*, 1647–1648.

Voogt, J.; Laferriere, T.; Breuleux, A.; Itow, R. C.; Hickey, D. T.; and McKenney, S. 2015. Collaborative design as a form of professional development. *Instructional science*, 43(2): 259–282.

Wing, J. M. 2006. Computational thinking. *Communications of the ACM*, 49(3): 33–35.

Yeter, I. H.; Yang, W.; and Sturgess, J. B. 2024. Global initiatives and challenges in integrating artificial intelligence literacy in elementary education: Mapping policies and empirical literature. *Future in Educational Research*, 2(4): 382–402.

Yim, I. H. Y.; and Su, J. 2025. Artificial intelligence (AI) learning tools in K-12 education: A scoping review. *Journal of Computers in Education*, 12(1): 93–131.

Zhang, H.; Lee, I.; Ali, S.; DiPaola, D.; Cheng, Y.; and Breazeal, C. 2023. Integrating ethics and career futures with technical learning to promote AI literacy for middle school students: An exploratory study. *International Journal of Artificial Intelligence in Education*, 33(2): 290–324.

Zhou, X.; Li, Y.; Chai, C. S.; and Chiu, T. K. 2025. Defining, enhancing, and assessing artificial intelligence literacy and competency in K-12 education from a systematic review. *Interactive Learning Environments*, 1–23.