Promoting AI Literacy in K-12: Components, Challenges, and Opportunities

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Abstract:
SRI Education researchers conducted an expert interview series, engaging a diverse group of researchers and practitioners in meaningful conversations about AI literacy in K–12. Drawing from these in-depth interviews with qualitative analysis, this report uncovers key themes that reveal the current state of AI literacy in K–12, the challenges we face, and the opportunities available to collectively advance AI literacy. By presenting these insights, this report aims to inspire and promote the community in reimagining AI literacy efforts, ensuring that teachers and students are prepared and equipped to thrive in today's technology-driven and AI-mediated world.

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Introduction

The prevalence of artificial intelligence (AI) and AI-powered technology is now integrated into many sectors, including education, with the potential impact and transformation of traditional practices and norms.[1] This rapid evolvement of AI technologies and integration has driven many countries and jurisdictions to prioritize AI education, especially at the K–12 level, to promote AI-literate citizens.[2] AI is broadly defined as "the science and engineering of making intelligent machines, especially intelligent computer programs" (p. 2).[3] Hence, AI systems and technologies are often based on algorithmic insights generated from established rules and environmental inputs, which could bring challenges and potential risks (e.g., algorithmic bias) along with promises and benefits. As a result, various initiatives and frameworks have been developed to define AI literacy, which many argue is essential for students to learn in K–12 education and become a collaborator and creator of AI than a consumer of AI products and AI-generated contents.[4]

Some of the first AI literacy and education frameworks developed include the "Five Big Ideas in AI" suggested by Touretzky and colleagues,[5] Long and Magerko's competencies within AI literacy,[6] and the AI literacy cognitive domains by Ng and colleagues.[7] Others have recently developed slightly different but related AI literacy frameworks.[4,8] Although there are differences in these frameworks, most define AI literacy as an individual's capability and confidence to clearly explain how AI technologies function and affect society, to use AI technologies ethically and responsibly, and to communicate and collaborate effectively with AI technologies in any context.[4]

However, as generative AI (GenAI) and large language models (LLMs) become increasingly integrated into education and daily life, it is important for the community to critically reflect on and rethink AI literacy efforts in K–12 education. To support this crucial endeavor, SRI Education researchers conducted an expert interview series, engaging a diverse group of researchers and practitioners in meaningful conversations about AI literacy in K–12. Drawing from these in-depth interviews and qualitative analysis, this report uncovers key themes that reveal the current state of AI literacy in K–12, the challenges we face, and the opportunities available to collectively advance AI literacy. By presenting these insights, this report aims to inspire and promote the community in reimagining AI literacy efforts, ensuring that teachers and students are prepared and equipped to thrive in today's technology-driven and AI-mediated world.

Approach

For this report, we conducted semi-structured interviews with nine experts in the field of AI education and AI literacy. Before conducting the interviews, we completed an environmental scan of the literature to understand current approaches to AI literacy in K–12, focusing on available tools and existing frameworks for integration. Based on these findings, we then constructed an interview protocol with a set of questions related to the operationalization and integration of AI literacy in K–12. The questions focused on three key topics: (1) the operational definition of AI literacy used in each expert's work; (2) the current needs, successes, and challenges of interdisciplinary AI literacy integration in K–12; and (3) the types of support that teachers would need to integrate AI literacy into their teaching practices (Table 1).

Table 1. CIGALE Expert Interview Protocol Topics and Example Questions

Topic	Example Questions
Operational definition of AI literacy used in the expert's own work	How do you define AI literacy in your work or research? How does this definition shape your approach to AI education? Connecting with the grade bands in which you have grounded your work and research, what are the key knowledge and skills individuals should acquire to be AI-literate?
Current needs, successes, and challenges in AI literacy integration in K–12	Based on your definition of AI literacy and expertise, what approaches might be most effective for integrating AI literacy into K–12 education? In your view, what are the key current and future needs for advancing AI literacy integration in K–12 education?
Types of support teachers need to integrate AI literacy into their teaching practices	From your experience, how do you view teachers' role in AI literacy integration in K–12? What knowledge and skill sets should teachers have to help students and teachers themselves develop AI literacy?

Using the interview protocol, we interviewed the nine subject matter experts, who were all working within AI literacy in the K–12 space within the U.S. context. The backgrounds and expertise of all interviewees are summarized in Table 2. All interviews were recorded, and eight were transcribed verbatim using Zoom's transcribe feature. A researcher also took detailed notes during each interview. The notes, recordings, and transcripts were qualitatively analyzed by creating a summary for each interviewee, which two researchers then used for thematic analysis and discussion to extract key takeaways and common themes across interviews.

Table 2. Expertise and Experience of Interviewed Subject Matter Experts

Expert	Expertise and Experience Related to AI Literacy
Jessica Vandenberg	Research scientist at a large state university AI Literacy Work: Research focuses on AI and computer science integration in upper elementary classrooms
Randi Williams	Program manager at an advocacy group focused on AI ethics AI Literacy Work: Designing AI literacy curricula for pre-K to 8th grade
Shiyan Jiang	Assistant professor at a large state university AI Literacy Work: Research focuses on AI literacy, with an interest in integrating digital literacy into STEM learning
Kip Glazer	High school principal AI Literacy Work: Focus on applying AI education research into practice at her school and beyond
Tingting Li	Assistant professor at a large state university AI Literacy Work: Research on science education, with a focus on using innovative technologies to support learning
Amy Eguchi	Assistant professor at a large state university AI Literacy Work: Part of the AI4K12 initiative, with a focus on teacher professional development in AI
Tara Nattrass	Managing director of innovation strategy at a large education nonprofit AI Literacy Work: Professional experience focuses on AI technologies, digital citizenship, and higher education
Sofía De Jesús	Associate program manager at a large research university AI Literacy Work: Professional experience and research focuses on advocacy and equity work as it relates to creating AI literacy guidelines and practices
Mike Kentz	Founder and CEO of a consultancy and training service focused on AI in education AI Literacy Work: Professional experience working with schools as a professional development provider to share his AI literacy approach

Key Findings

The sections below describe key takeaways and common themes from the expert interviews. Specific quotations and ideas throughout are from the experts in the table above, credited in parentheses following a quotation or idea.

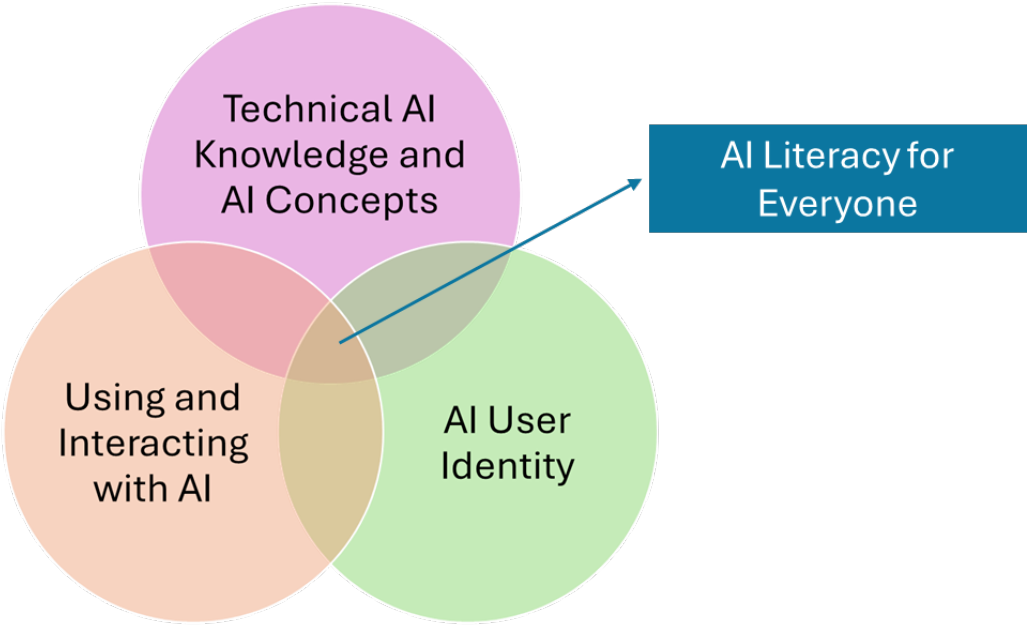
Defining AI Literacy

Three interrelated areas of knowledge emerged as key pillars of AI literacy in K–12 education during our expert interviews (Figure 1). The first pillar focuses on providing students with ***a fundamental understanding of what AI is***. This information is the "first step" (Eguchi), which can serve as the foundation for building more nuanced understandings of AI and AI literacy. Key concepts mentioned during the interviews to support this pillar ranged from sorting to the predictive and algorithmic nature of AI. However, defining "foundational knowledge" varies depending on the context. When we think about AI literacy, we must consider what all students need to know as they engage with AI across disciplines as well as what smaller groups of students need to know as future AI developers (Nattrass). Thus, operationalization of AI literacy must reflect these layers and nuances regarding technical AI knowledge.

The second pillar of AI literacy emphasized ***interactions with AI***, including ways of creating, using, and applying AI knowledge and tools. This pillar reflects that "the one stage we want all students to be, no matter what their prior knowledges are, is about students being a power user" of AI (Jiang). At the core of this pillar is the empowerment of students by having them "become creators, not just consumers of AI" (Williams).

As AI-empowered creators, students then need to develop ***AI user identities*** that recognize their self-agency, which constructs the third pillar of AI literacy. To foster such identities, AI literacy must include the ethics of AI (Jiang, Williams). These considerations center on questions such as "Where did these models come from?" "Is the data accurate?" and "What are the terms of service?" (De Jesús). Students' understanding of the technical aspects of AI can also be leveraged to help them recognize why these ethical questions arise. Additionally, students should be encouraged to evaluate the potential risks and benefits of AI from multiple perspectives, such as harmful bias, safety and security, and misinformation (Nattrass). Such understandings can then promote "the safe, responsible, and effective use of AI" (Kentz) by students for social good.

Figure 1. **Three Interrelated Areas of Knowledge Forming the Pillars of AI Literacy in K–12.**



Learning Progression for AI Literacy

The experts' three-pillar definition of AI literacy above illustrates that "AI literacy is layered and interconnected" (Glazer). Based on this definition, the experts described an operationalization of AI literacy in K–12 that balances and layers these technical and nontechnical components in a learning progression (Kentz, Jiang, Nattrass, Vandenberg, Williams) that is developmentally appropriate (Eguchi, Glazer).

When conceptualizing AI literacy from prekindergarten to elementary school, the experts recommended an introduction of AI that focuses on key ideas instead of the technical terms to reflect the developmental stage of the students. For example, concepts can be broken down and scaffolding increased because younger students do not have the abstract reasoning skills and background knowledge to evaluate the outputs from AI tools (Eguchi). Relatedly, GenAI tools are not needed to teach AI literacy in elementary school; instead, AI literacy can focus on foundational concepts rather than on specific tools (Nattrass). Within this unplugged and hands-on approach, multiple experts highlighted the importance of "creating interest" (Jiang). This can be achieved by focusing on real-life problems and using project-based instruction to help students find and iterate on potential solutions (Glazer, Williams). For K–2, collaboration, creation, and physical play are also central (Williams). Ultimately, building this foundation is important to give students the core concepts and curiosity that can be further developed in middle and high school (Nattrass, Vandenberg).

According to the experts, middle school AI literacy should leverage the emerging interests of students across different topics by highlighting the connection between AI and the students' fields of interest (Jiang). Thus, instruction will be "interest-focused" and based on "human-computer perception" at this grade band (Glazer). As students tackle more complex problems in project-based instruction, they can also start exploring topics such as the limitations of AI and AI ethics (Jiang, Williams). Thus, middle school AI literacy can leverage the curiosity and background from the earlier grades to delve deeper into the second and third pillars of AI literacy defined by the experts.

As students start thinking about their career goals and college majors in high school, AI literacy should further focus on the students' individual interests and the role of AI in their chosen fields (Jiang). Thus, AI literacy programming should investigate how AI contributes to different fields, with a focus on how the industry uses AI (Jiang, Nattrass). Students' budding specializations also necessitate considering what is critical for different students to know when it comes to AI literacy in high school (Eguchi, Nattrass). For example, "general students might not need to learn something more complex, but somebody who is interested in going into CS [computer science] or even AI … needs more foundation" (Eguchi). With students' increased subject knowledge, high school AI literacy can also cover more technical concepts to "demystify AI" through using the tools or interactive demos (Jiang). This can further make AI feel "approachable," "understandable," and "accessible," empowering students (Jiang).

Although the experts primarily conceptualized the above learning progression for AI literacy by grade bands, they also highlighted the different understandings and uses of AI across subject areas (Jiang, Vandenberg, Williams). Although AI literacy is most frequently included in computer science education, starting from a different subject as the basis can allow students to review other, perhaps less technical, AI topics (Williams). Further, science, math, or computer science classes could focus on the machine literacy topics, while humanities could include AI literacy in the essay writing process and project-based learning exercises (Kentz). During this progression by grade band and subject area, ideas such as ethics, cybersecurity, and privacy can serve as repeating "threads" (Jiang). Ultimately, these connections and increasing layers of complexity can form an upward "spiral" (Williams) for cultivating AI literacy within K–12 education.

Challenges and Needs

As an emerging focus, preparing AI-literate generations presents unique challenges and needs. At the student level, the experts highlighted that students use AI tools and learn about AI even before engaging in any AI literacy curriculum (Jiang, Williams). Although this "pre-knowledge" can be accurate, it often includes misconceptions about AI (Jiang). Students' AI literacy experiences in the classroom may vary significantly based on these prior beliefs (Williams). For example, media portrayals of sentient robots can lead students to believe AI has feelings

(Williams). Thus, teachers must understand these trends and recognize students' existing perspectives on AI.

However, it is also important to acknowledge that teachers often learn about AI alongside their students (Li, Nattrass, Vandenberg). Because most teachers do not have a computer science background, they need to build a basic understanding of AI as they critically engage with AI tools and model correct understandings for their students (Li, Nattrass). Thus, teacher AI literacy must be prioritized to effectively integrate AI literacy into K–12 classrooms (Li, Nattrass).

Another challenge stems from the differences between AI and traditional education tools. In AI-enhanced education, AI tools can enable real-time and personalized responses to students, which is not always possible with traditional methods (Glazer). This can then allow for more process- and competency-focused pedagogies, in contrast to traditional information-based approaches (Glazer, Nattrass). With "more flexible and adaptable learning environments" (Nattrass), the teacher's role also changes from information provider to facilitator and designer of learning (Eguchi, Nattrass, Vandenberg). However, this reimagining can be naturally uncomfortable for teachers as they need to be open to learning alongside their students (Glazer, Vandenberg). For example, when providing AI literacy professional development (PD), one expert's team receives requests to "co-teach" because teachers are afraid that they cannot answer students' questions about AI (Vandenberg). Thus, the team's PD work aims to enhance teachers' AI background while making them "comfortable not knowing everything" (Vandenberg). There is also a need to clarify for teachers how such learning experiences should look (Nattrass). Thus, teachers need support in developing their "AI educator identity" (Jiang) when integrating AI literacy into K–12 education.

Ultimately, in all expert interviews, teacher PD emerged as the key support for teachers in navigating these challenges. PD opportunities related to AI literacy starting in preservice teacher education programs can be especially helpful in the long-term, as such approaches could help reduce demanding needs for current teacher PD (Eguchi). Unfortunately, the current demand for AI literacy PD is too high to be met (Nattrass), alongside a scarcity of quality programs provided by qualified professionals (De Jesús). There is also a lack of AI literacy standards that can be shared with teachers as part of their PD to guide their AI literacy implementation (Eguchi, Jiang, Kentz, Nattrass). Given teachers' busy workloads, creating AI literacy standards can streamline integration of AI literacy and incentivize teachers to prioritize it (Eguchi, Jiang). Further, clarifying how these AI literacy standards align with existing standards may make them easier to incorporate into classrooms (Nattrass).

When creating PD opportunities, the experts also stressed the importance of recognizing teachers' busy schedules (Jiang, Li). Thus, AI literacy and tools could be framed in terms of how they can solve the problems teachers are encountering (Li, Vandenberg). A key consideration at each stage of AI literacy integration should be "Can we make things more practical for teachers?" (Williams). Relatedly, school administrators and districts leaders should provide

teachers with the resources, time, and space to complement the PD opportunities. There is currently a need for more "top-down guidance" on how to use AI tools in the classroom (Williams), which requires "expertise at the administrative level, so that they can not only support but also mimic" expectations (De Jesús). Not all teachers have access to the internet or computers in the classroom, which can also limit the opportunities for AI literacy integration (Glazer, Vandenberg). If possible, teachers could receive monetary incentives for integrating AI literacy (Kentz). Amid competing priorities, incentives can allow teachers to prioritize AI literacy (Kentz), especially if combined with AI literacy standards.

Opportunities

While discussing current challenges and needs, the experts also highlighted several ongoing efforts and opportunities aimed at promoting AI literacy in K–12. For instance, after high school English teachers deliver essential content and information, GenAI-embedded chatbots could be used to support writing exercises. In a weeklong unit, one expert asks students to provide their chat history and transcripts from these writing exercises (Kentz). This approach helps to assess how students interact with the chatbot and how their thought processes evolve throughout such interactions (Kentz). More importantly, "I can see in the transcripts whether or not the bot is helping my student or hurting my student. I can see in the transcript whether or not my student understands the nature of the bot itself, and what it's supposed to help with, and what it's not supposed to help with right on the page. … The other way is verbal communication. … So, what I did with my students when they finished and I knew they had used AI is, everyone is going to come up and present their essay without notes. … [You] can tell within the first 30 seconds whether or not the student understood the concept or not" (Kentz). Such insights provide information on how students grasped the materials, compared with a single written submission.

In addition to AI technologies integrated as an augmenting tool and reinforcement mechanism in English classes, there are also programs designed to help high school students demystify AI and gain a deeper understanding of how AI functions. These programs often involve students engaging in interactive demos of how AI functions and in the creation of AI models. Such projects usually "hope to demystify foundational AI models so that [students] feel that it's accessible. They can see that [there's] a human's role in making those models" (Jiang).

For middle school students, some current initiates aim to engage them as "AI power users" in solving problems using AI technologies (Jiang). To connect AI to middle school students, teachers often need to understand "what students were experiencing in their lives" and "help students build knowledge to address some of the misconceptions that would come up" (Williams). For instance, one expert's approach is to "start a lot of my AI courses with, like, a perspectives thing like, okay, here's some statements about AI. Go to this side of the room if you believe that. Go to that side of the room if you believe that and, like, let's just talk. And then we'll break down into using things and learning more. But, if there's not space for that, then it can only be helpful to give students exposure in the ways that it can be accessible" (Williams).

Moreover, every lesson "would try to be as hands-on as possible, would try to be as, like, nuanced as possible, and it would try to stay grounded in what students were actually caring about and seeing in the world. So, it was really led by them in a lot of ways" (Williams).

In addition, the experts also mentioned some efforts to design quality PD sources for preservice and in-service teachers. Teachers have a key role in promoting AI literacy in K–12, and they need to know some AI basics and beyond (Li). In fact, teachers "already know AI is here and that it is going to impact them in their classrooms, for good or bad. And because of that, they want to know as much as they possibly can about specific tools, for example, but also they want to know how they can use it to their benefit … they are asking for this" (Vandenberg). Although some teachers have already used commercial AI products in their daily work, it is particularly crucial to support teachers in analyzing AI-generated outputs, especially teachers who do not have a strong background (e.g., in science). For example, one expert designed activities to help preservice teachers conduct a detailed analysis of AI-generated outputs related to science through evaluation and reflection (Li). The goal of these activities is to enable teachers to better understand, reflect on, and reconsider the affordances, limitations, and risks of AI technologies and the generated outputs.

The experts also underscored the importance of providing PD that is practical and immediately usable by teachers (Eguchi, Jiang). On expert does "a lot of online PD workshop[s] to provide the teachers the kind of examples … that teachers can easily pick up and use. So, when we do online lessons, we provide not only … sequence of lessons but also provide materials. And then, you know, examples of handout to the students. Extra information that teachers can use" (Eguchi). More specially, teacher PD should not merely include fundamental AI concepts. Instead, PD should be designed to reach all teachers, including non-computer science teachers, and advocate for a culture where teachers feel comfortable acknowledging gaps in their AI knowledge. The aim is to get "teachers to take on the role of facilitating and saying to the students, 'You know what? I don't know the answer to that. How can we figure it out?'" (Vandenberg).

Reflection and Recommendation

In this report, we present key findings from nine diverse experts in education to elicit insights related to AI literacy in K–12 education. We especially represent the experts' thinking about the definition of AI literacy in current educational settings, challenges and needs in promoting AI literacy in K–12, and ongoing efforts with promise to promote AI literacy in K–12 both for students and teachers.

Reflecting on the findings discussed above, we see an urgent need to advance AI literacy in K-12. However, such advancement requires several important factors. First, educators should embrace the mindset that newer paradigms, such as personalized learning, could be accelerated by AI technologies. While recognizing the benefits of AI-driven tools in customizing instruction and providing real-time feedback to empower students to learn and grow, teachers should also be aware of the changes in pedagogies (such as effective integration of AI tools with responsible use, assessment, etc.) in response to the use of AI technologies in classrooms. To achieve such goals, teachers must feel confident and competent in interpreting AI-driven data and in using such data to understand student learning and inform their teaching strategies. However, to ensure successful AI literacy integration and implementation, school leaders must support teachers through quality PD and resource allocation, including providing training on effectively integrating AI tools into teachers' pedagogical practices. By embracing continuous and tangible PD, we can prepare teachers with the skills and practices necessary to integrate AI literacy and cultivate AI literacy in students.

Further, to navigate the challenges and opportunities of promoting AI literacy in K–12 education, we need to foster ongoing conversations with teachers and other community interest holders about promoting AI literacy. A few experts raised a challenge regarding the potential for students to misuse GenAI tools to "cheat" in academics, and educators should have a holistic evaluation of the benefits and limitations of AI tools in education and continue to explore promising new ways to use AI effectively and responsively in the classrooms.

AI literacy is not a stand-alone discipline, and we need to explore the synergies between AI literacy and other disciplines. For example, integrating AI with science education can help students understand data analysis, pattern recognition, and simulation modeling. Such cross-disciplinary conversations ensure that AI literacy is not isolated but embedded into a broader educational context to enrich students' understanding of how AI intersects with different fields and real-world challenges.

Sharing our collective knowledge and experiences related to AI literacy is crucial for keeping pace with AI's rapid advancements. As GenAI technologies continue to evolve and other new trends of technological innovation emerge, our understanding of AI literacy must also adapt. Educators, researchers, and industry professionals should collaborate to disseminate insights into effective curriculum development, classroom resources, instructional strategies, and

real-world applications. By sharing such resources, we could help broader K–12 ecosystems stay informed about AI literacy and, therefore, promote a learning culture where best practices are identified, refined, and scaled.

Endnotes

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