K-12 Education in the Age of AI: A Call to Action for K-12 AI Literacy

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Abstract

The emergence of increasingly powerful AI technologies calls for the design and development of K-12 AI literacy curricula that can support students who will be entering a profoundly changed labor market. However, developing, implementing, and scaling AI literacy curricula poses significant challenges. It will be essential to develop a robust, evidence-based AI education research foundation that can inform AI literacy curriculum development. Unlike K-12 science and mathematics education, there is not currently a research foundation for K-12 AI education. In this article we provide a component-based definition of AI literacy, present the need for implementing AI literacy education across all grade bands, and argue for the creation of research programs across four areas of AI education: (1) K-12 AI Learning & Technology; (2) K-12 AI Education Integration into STEM, Language Arts, and Social Science Education; (3) K-12 AI Professional Development for Teachers and Administrators; and (4) K-12 AI Assessment.

Keywords AI education · K-12 education · K-12 AI education · Computer science education

Artificial intelligence (AI) is a profoundly transformative technology. Recent years have seen the emergence of powerful advances in AI that are quickly finding their way into every sector of industry and government and bringing about extraordinary developments in science, business, law, agriculture, transportation, security, and medicine. It has become clear that virtually no aspect of society will be untouched by AI. Further, the magnitude of these impacts is increasing, and the rate of these

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changes is accelerating. In short, we are rapidly entering a new era, the "Age of AI," which has world-changing implications for K-12 education.

When today's students enter the workforce, they will join a labor market that will have undergone a major shift from previous generations and be radically reshaped by advances in AI. AI holds not merely the potential to disrupt the labor market, it is clear that it will radically reshape what jobs are available, how they will be performed, and how workers should be prepared for them. Workers will share their jobs with AI, with most jobs featuring workers' sharing responsibilities with AI systems. Industry will place a premium on "AI teaming" competencies that enable workers and AI to collaboratively solve problems with each playing roles that build on their respective strengths. Human-AI teaming will reward those workers who develop the ability to understand what tasks can best be performed by AI, what an AI system's capabilities are, and how "AI job sharing" can best be accomplished.

We must re-envision K-12 education to prepare for the reality that AI will be prominently featured in every aspect of students' lives, including their work lives. K-12 education in the Age of AI must cultivate students' ***AI literacy***, which we define as follows:

> AI literacy is the ability to readily engage with AI by leveraging AI tools, systems, and frameworks to effectively and ethically solve problems in a wide range of sociocultural contexts.

Our framing of AI literacy has three key components:

- ***Understanding AI capabilities***: Workers will be required to understand AI capabilities at varying levels of technical expertise, which will range from essentially no technical expertise at all to deep knowledge of the theoretical underpinnings of state-of-the-art AI. The level of technical expertise required will be dependent on the tasks associated with a job: most tasks and jobs will require modest technical expertise or no technical expertise at all; AI engineering tasks will require substantial technical expertise; and AI research will require the highest levels of technical expertise. Different jobs and tasks will also require varying levels of AI teaming expertise.
- ***Utilizing AI for problem solving***: Workers will be required to apply AI tools, systems, and frameworks to solve a broad range of problems. Applying AI to solve problems will span cognitive, perceptual, psychomotor, and communicative tasks. Workers will be required to utilize AI to solve problems effectively, efficiently, and ethically. They will need to develop solutions to problems that are correct, address necessary time constraints, and consider the myriad ethical issues bearing on their tasks.
- ***Applying AI in sociocultural contexts***: Workers will need to be able to readily work with AI in a variety of contexts. The broader social and cultural dimensions in which AI is applied will significantly affect its utilization. For example, workers will need to be able to engage in AI teaming while also attending to sociocultural issues of communication and interaction where appropriate problem

solving is contingent on the traditions and norms of a particular workplace and the broader society in which it is situated.

To cultivate AI literacy in students, K-12 education should introduce *all* K-12 students to the fundamentals of AI as well as provide an on-ramp to advanced AI education through a series of learning progressions for students who wish to pursue technical careers in AI. Beginning in elementary grades, students should begin developing AI literacy through examples of how AI manifests in widely used software and being introduced to social issues in AI. In middle school, AI literacy should focus on age-appropriate AI technical concepts that provide a foundation for future studies, and it should encompass social aspects of AI that enable students to understand the broader contexts in which AI is deployed. In high school, AI education should continue to be universal, i.e., required of all students, and advanced AI coursework should be available for students who may elect to pursue AI engineering and AI research careers. It is important to note that AI literacy does not entail requiring all students to engage with advanced concepts or mathematical foundations of AI. AI literacy, however, should require all students to develop a solid understanding of AI capabilities, their limits, their application, and the ethical considerations bearing on their use.

Developing, implementing, and scaling an AI literacy curriculum poses significant challenges. It will be essential to develop an evidence-based AI education research base that can inform AI literacy curriculum development. We do not currently have a research foundation for how AI is learned, how AI learning progressions should proceed, how AI education should be integrated into STEM, language arts, and social science education, how AI should be taught, and how AI learning should be assessed. Funding agencies have begun to recognize this shortcoming, and we are seeing the very early emergence of AI education research, but it is still in its nascent form. While experimental AI curricula have sprung up internationally, these are not informed by evidence-based pedagogies. A significant concern is that the enormous and growing demand for K-12 AI education is beginning to result in the adoption and implementation of curricula that are not grounded in education research.
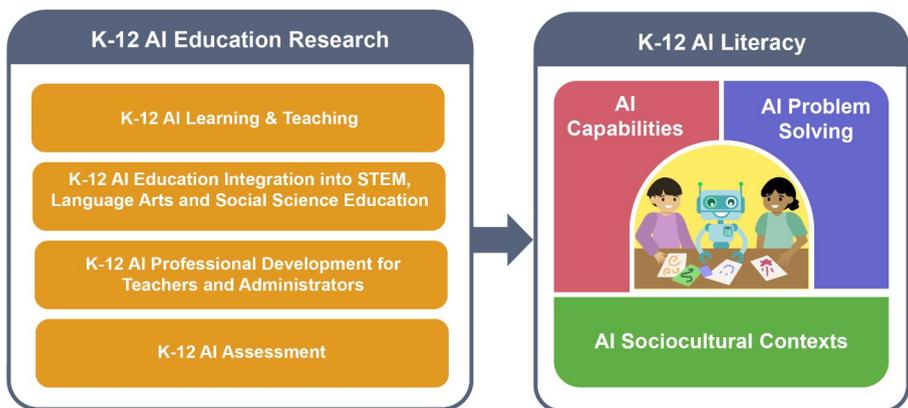

Fig. 1 Building the educational research foundation for K-12 AI literacy

Given the global economic and societal importance of AI, we must develop a robust foundation for K-12 AI education. Following the lead of the science and mathematics education research communities, which have produced firm foundations for K-12 science and math education, and leveraging advances in computer science education research, research programs should be developed for four areas of K-12 AI education (Fig. 1):

- **K-12 AI Learning & Teaching**: We need to develop an understanding of how to design effective frameworks and methods for learning and teaching AI in K-12 schools. Design principles for K-12 AI education should be theoretically grounded in the learning sciences, STEM education research, and educational psychology. In addition to informing the design of curricula for AI conceptual knowledge and problem-solving practices, they should also inform the design of learning experiences that give primacy to AI ethics and the social impact of AI. Research should be conducted on AI learning progressions, and AI education should be investigated in both formal and informal learning contexts. Finally, the emergence of increasingly powerful AI technologies calls for the investigation of AI-driven learning technologies to support learning and teaching of AI (i.e., AI learning technologies supporting AI as a subject matter), with opportunities for leveraging advances in explainable AI being particularly intriguing.

- **K-12 AI Education Integration into STEM, Language Arts and Social Science Education**: Because AI will play an increasingly important role in every discipline and in every sector of the economy, we must develop an understanding of how to develop an integrated model of K-12 AI education that infuses AI throughout the curriculum. For example, students must become adept at using AI in science and math, as well as in language arts and social science. We need to develop innovative approaches to integrative AI-science, AI-math, AI-language arts, and AI-social science education. Doing so will not only yield more effective approaches to, for example, "doing science," it will also address the practicalities of school curricula that are already exceedingly full.

- **K-12 AI Professional Development for Teachers**: We must develop an understanding of how to create the most effective AI professional development (PD) for K-12 teachers. Doing so will entail creating a research program in design principles for creating professional development around both AI content knowledge and AI pedagogical knowledge. K-12 AI PD research should investigate approaches that can effectively take into account the broad range of competencies in AI that teachers and administrators begin with. While exploring K-12 AI PD methods for in-service teachers is critical, it will be equally important to do so for pre-service teachers as well.

- **K-12 AI Assessment**: We must develop frameworks for assessing students' AI competencies. To best support the broader enterprise of K-12 AI education, we need to create innovative approaches to measuring students' conceptual understanding of AI, their proficiency in using AI in problem solving, and their ability to address considerations of AI ethics. In addition to developing new instruments that use rigorous approaches for assessing AI competencies, we need to investigate new methods and technologies (including AI-driven assessment

technologies) that can reliably measure AI conceptual knowledge, problem-solving practices, and ethical foundations.

As the demand for K-12 AI education continues to grow, and every sign points to its exceptionally rapid growth, education policy makers across the globe should promote the development, implementation, and scaling of a comprehensive K-12 AI literacy curriculum that is designed to support all students, not just those who will pursue R&D AI careers. Beginning in elementary school and continuing through secondary school, a robust AI literacy curriculum will enable today's K-12 students to flourish in the Age of AI.

Declarations

Conflicts of Interest No potential conflicts of interest.