IOSR Journal of Research & Method in Education (IOSR-JRME)
e-ISSN: 2320–7388, p- ISSN: 2320-737x Volume 15, Issue 3 Ser. 1 (May. – June. 2025), 24-29
www.iosrjournals.org

Deep Learning For School-Age Children In The Artificial Intelligence Era: An Educational Imperative

Doan Thi Hue Dung
The Saigon International University, Vietnam

Abstract
Background: *As artificial intelligence (AI) continues to transform society, educational systems must adapt to equip learners with competencies that transcend rote memorization and passive knowledge acquisition. This paper explores the pedagogical necessity of fostering deep learning in school-age children as a strategic response to the pervasive integration of AI in education. Deep learning—marked by critical thinking, knowledge synthesis, creative inquiry, and real-world application—stands in contrast to surface-level engagement and is increasingly vital in AI-mediated learning environments.*
Materials and Methods: *Drawing on a review of relevant literature and theoretical frameworks, the study examines the core attributes of deep learning, evaluates current uses of AI tools in schools, and identifies key competencies required of school children for effective learning in the AI era.*
Conclusion: *The paper offers evidence-based recommendations for educators and policymakers aimed at embedding deep learning principles into curriculum design and instructional practice. It advocates for a reimagined educational paradigm that foregrounds human cognitive strengths and prepares learners to critically engage with and shape AI-influenced futures.*
Keywords: *artificial intelligence, deep learning, school-age learners, AI integration in education, critical thinking*

Date of Submission: 27-04-2025 Date of Acceptance: 07-05-2025

I. Introduction

The accelerating development and integration of artificial intelligence (AI) into everyday life are transforming nearly all facets of society, including the way we teach and learn. In classrooms and at private learning places, AI technologies such as ChatGPT and Gemini, adaptive learning platforms, and intelligent tutoring systems are becoming increasingly prevalent. These tools offer unprecedented access to information and personalized learning experiences. However, this rapid technological progress also highlights a critical weakness in traditional education: its ongoing reliance on surface learning strategies—such as repetition, memorization, and standardized responses. In the context of AI, these approaches are not only insufficient but potentially harmful. When learners, especially children, depend on shallow learning methods, they risk becoming passive recipients of AI-generated information rather than active thinkers. Without the ability to critically filter content or pose meaningful, context-relevant questions to AI systems, students may absorb inaccurate or biased outputs, undermining genuine understanding. Thus, equipping learners with deep learning skills is no longer optional, but essential for navigating and mastering the AI-enhanced knowledge landscape. More importantly, as machines take over routine cognitive tasks, it becomes essential to cultivate those uniquely human capacities that AI cannot easily replicate—namely, critical thinking, ethical reasoning, creativity, collaboration, and adaptability.

This article explores the concept of deep learning as a pedagogical response to the demands of the AI era, with a specific focus on school-aged learners. Deep learning involves the development of higher-order thinking skills and the capacity to apply knowledge across contexts, a necessity for navigating the complex, unpredictable challenges of an AI-driven world. The aim of this paper is to discuss why deep learning must become a foundational element of modern schooling. It begins with a conceptual definition of deep learning, followed by an overview of its characteristics, a discussion of current AI tools in education, an exploration of essential student competencies, and practical recommendations for educators.

II. Perspectives And Implications

Understanding Deep Learning in Education

The term "deep learning" was first introduced by educational researchers Ference Marton and Roger Säljö in their seminal 1976 study, which explored how university students engaged with academic texts. Through this research, they identified two qualitatively different approaches to learning: surface learning, where students

focus on memorization and reproduction of information, and deep learning, where learners seek to understand meaning, connect ideas, and apply knowledge in broader contexts. Marton and Säljö defined deep learning as a process characterized by intentional engagement, critical thinking, and conceptual integration, emphasizing that students who adopt this approach are more likely to retain knowledge meaningfully and transfer it across domains [1]. The significance of deep learning in education lies in its alignment with the goals of transformative, lifelong learning. It shifts the focus from passive absorption to active construction of understanding, fostering the development of higher-order thinking skills. This foundational concept has profoundly influenced curriculum design, assessment strategies, and instructional methods at all levels of education.

Many educators view deep learning as a process in which learners engage meaningfully with content, making connections between concepts, applying knowledge in new situations, and developing a lasting understanding of ideas [2]. Unlike surface learning—which is characterized by memorization and a focus on test performance—deep learning encourages students to question assumptions, seek understanding, and integrate knowledge across domains. According to Fullan et al. [3], deep learning fosters six key global competencies: character, citizenship, collaboration, communication, creativity, and critical thinking. These competencies are essential for learners to become active, engaged, ethical, and capable contributors in a rapidly evolving world.

The growing consensus among educators is that deep learning must replace outdated methods that treat students as passive recipients of knowledge. Bransford et al. [4] emphasize the importance of engaging students in tasks that are meaningful, contextually relevant, and aligned with how knowledge is used outside the classroom. Research by Do et al. [5] supports this view, emphasizing the need for learners to develop metacognitive awareness, self-direction, and reflective habits as they progress through increasingly complex academic challenges. These skills, they argue, are vital to promoting long-term retention, self-regulated learning, and adaptability in unpredictable learning environments.

The need to revisit deep learning implication in the AI era

In the era of artificial intelligence, deep learning is not only relevant, it is more essential than ever. With AI-powered tools such as intelligent tutoring systems, automated feedback generators, and generative content platforms increasingly present in classrooms, learners are surrounded by instant answers and algorithm-generated insights. While these technologies offer great assistance, they also risk reinforcing surface-level engagement, particularly if students interact with them passively, without the skills to question, interpret, or contextualize what they receive. This challenge is especially acute for school-age children, whose cognitive and metacognitive capacities are forming. When used uncritically, AI can deliver quick answers that bypass the need for understanding, analysis, or reflection. Selwyn [6] cautions that unstructured reliance on AI may undermine students' engagement in essential higher-order thinking processes like evaluation, synthesis, and creativity.

At this formative stage, children require a new set of learning competencies to learn effectively such as critical evaluation of AI content, creative inquiry, ethical reasoning, and self-regulated learning. Deep learning in the artificial intelligence era must, therefore, evolve into a framework that not only promotes understanding of content but also encourages learners to construct meaning, pose original questions, and apply knowledge across contexts. Deep learning also nurtures students' capacity to make connections across ideas, and build personal, lasting understanding [3].

AI systems, including ChatGPT, are trained on vast datasets that can reflect social biases. If learners are not taught to critically evaluate AI outputs, they risk internalizing biased or inaccurate information. Deep learning develops critical literacy and ethical awareness, enabling learners to question the reliability and implications of machine-generated content.

Characteristics of deep learning learners

Deep learning learners are distinguished by a number of cognitive, behavioral, and emotional traits that set them apart from surface learners. They exhibit a strong sense of intrinsic motivation, often driven by curiosity and a desire to understand rather than merely to complete tasks. They approach problems holistically, synthesizing information from various sources and disciplines to form well-reasoned conclusions [7]. Additionally, deep learners display a willingness to question assumptions, engage in self-assessment, and revise their understanding based on new evidence.

Self-regulation is another feature of deep learners. Zimmerman [8] defines self-regulated learners as those who proactively plan, monitor, and evaluate their learning processes. This requires a high level of metacognitive awareness and persistence, particularly when learners encounter difficulty. Do et al. [5] underscore the importance of this quality in today's educational landscape, noting that students who adopt deep learning approaches are better able to transfer knowledge across domains, adapt to new learning environments, and develop the kinds of flexible problem-solving skills needed in a knowledge economy.

Furthermore, deep learners are reflective. They not only learn content but also think about how they are learning and why certain strategies are effective. This reflective capacity enables them to take ownership of their

learning, identify areas for growth, and engage in continuous improvement. Such learners are also more likely to demonstrate empathy, ethical reasoning, and the ability to work collaboratively [3]. These skills are becoming increasingly valuable in AI-augmented societies.

How ChatGPT Works in Educational Interactions

ChatGPT is a large language model developed by OpenAI, based on the transformer architecture. It is trained using a technique called unsupervised learning on vast datasets that include books, websites, and dialogues. When interacting with learners, ChatGPT responds contextually. It analyzes the user's prompt and generates coherent, context-sensitive responses. ChatGPT also personalises explanations. Depending on how a learner phrases a question, ChatGPT can provide multiple levels of explanation, from simple definitions to deeper theoretical discussions. In addition, ChatGPT encourages exploration by prompting follow-up questions, model critical thinking, or suggest new areas of inquiry. Another prevailing ability of ChatGPT is its giving instant feedback. It can provide immediate reactions to student writing or problem-solving steps, helping with revision or comprehension. However, uncritical dependence on ChatGPT can lead to overconfidence in incorrect or biased answers, reinforcing the need for learners to develop metacognitive skills, verify sources, and engage in deep reflection.

Integration of AI in School Education

The incorporation of AI technologies into classrooms is no longer a futuristic vision. It is a present reality. Educational AI applications now support students in a wide range of tasks: from personalized math tutoring through platforms like Carnegie Learning to real-time writing feedback via tools such as Grammarly and ChatGPT. These systems utilize natural language processing, machine learning, and predictive analytics to adapt content to each learner's pace and style.

AI can be meaningfully integrated into various content-based subjects. In Mathematics, AI-powered tutors provide adaptive feedback, scaffold complex problem-solving, and visualize abstract concepts. Programs like Squirrel AI and Khanmigo tailor questions to individual learning levels. In language studies, common tools like ChatGPT, Grammarly, and AI-based reading assistants enhance reading comprehension, vocabulary development, and writing skills by offering real-time suggestions and analysis. In Science and STEM, simulations and virtual labs powered by AI allow students to experiment with scientific models and phenomena. AI tools also assist in coding instruction and logic-based reasoning. In social studies: AI can provide historical simulations, facilitate role-playing exercises, and analyze primary sources through natural language processing to support critical thinking. With art and creativity subjects, generative AI supports storytelling, visual arts, and music creation, enabling students to explore creative pathways while reflecting on ethical implications of machine-generated content. These applications highlight AI's potential to personalize instruction, deepen engagement, and foster inquiry across subjects.

AI's role in formative assessment and learning analytics is also growing. By tracking student interactions, engagement levels, and response patterns, AI can help teachers identify misconceptions, personalize instruction, and intervene early with at-risk students [9]. However, educators must balance data-driven decision-making with ethical considerations and ensure that AI supports, rather than substitutes, the human relationships at the heart of learning.

Common AI applications used in classrooms

AI is already making a profound impact on education, transforming both in-person classrooms and online learning environments. Its integration into day-to-day instruction has introduced powerful tools that personalize learning, enhance student engagement, and streamline educational operations. The growing presence of AI in classrooms signals a shift toward a more dynamic and responsive educational model. By blending intelligent technology with human instruction, schools can foster environments that are more personalized, inclusive, and better aligned with the demands of a rapidly evolving future. Below are some of the most significant current applications of AI in education, as highlighted by recent research and practical implementation:

1. Adaptive Learning Technologies

AI-driven learning platforms, like those adopted by institutions such as Arizona State University, employ machine learning to adjust instructional content in real time. These systems cater to each student's individual pace and learning needs, promoting deeper engagement and stronger academic performance.

2. AI-Generated Educational Content

Generative AI tools are now able to create personalized instructional materials, including quizzes, practice exercises, and review guides. These tools are especially valuable for students who require differentiated instruction, offering more inclusive and accessible learning resources.

3. Intelligent Tutoring Systems (ITS)

Educational software like DreamBox Learning, used extensively in elementary education, uses AI to monitor student progress and adapt lessons accordingly. Research from institutions like Harvard University has shown that such systems can significantly improve student achievement, particularly in foundational subjects like mathematics.

4. Immersive Learning with VR and AR

When paired with AI, virtual and augmented reality technologies can create rich, interactive simulations. These environments allow students to explore historical events, scientific processes, or complex concepts in ways that deepen understanding and make abstract topics more concrete.

5. Automated Assessment and Feedback

AI is also reshaping how students are evaluated. Automated grading systems provide immediate, targeted feedback that helps learners recognize and correct errors more efficiently, while also relieving teachers of time-consuming administrative tasks.

6. Chatbot-Based Student Support

AI-powered chatbots are being widely used to enhance student support services. Available around the clock, they assist with academic inquiries and administrative tasks, improving accessibility and responsiveness across educational institutions.

7. Emotional and Social Development Tools

AI technologies are increasingly being used to aid students with special needs, particularly in supporting emotional and social development. For instance, robotic companions are helping children on the autism spectrum practice communication and social interaction skills in safe, structured environments.

8. Predictive Analytics and Personalized Learning Paths

By analyzing patterns in student data, AI can recommend personalized learning trajectories and even anticipate future performance. This allows educators to identify struggling students early and tailor interventions to support long-term academic growth.

Deep Learning Skills Needed in the AI Era

School-age children urgently need to be equipped with deep learning skills because the rise of AI in education is not just changing *what* students learn, but how they learn, interact, and make sense of knowledge. In an AI-dominant learning environment, where information is abundant and answers are readily generated by machines, the ability to think critically, reflect deeply, and learn autonomously becomes essential for meaningful engagement and long-term success.These essential skills include:

1. Critical Evaluation

Students need the ability to assess the credibility, accuracy, and relevance of AI-generated content. Given that AI tools can produce plausible-sounding yet potentially flawed information, developing strong evaluative filters is crucial. Educators can facilitate this by engaging students in activities that analyze and critique AI outputs, enhancing their critical thinking skills.

2. Knowledge Integration

The skill to synthesize AI-provided insights with existing knowledge and interdisciplinary understanding is vital. This involves making conceptual connections and applying them to real-world contexts. Recent studies emphasize the importance of integrating AI literacy into curricula to foster such interdisciplinary learning.

3. Self-Regulated Learning

Students must develop the capacity to plan, monitor, and reflect on their own learning processes while using AI tools. AI applications can support self-regulated learning by providing personalized feedback and adaptive learning paths, encouraging students to set goals, track progress, and adjust strategies accordingly [10].

4. Creative Inquiry

While AI tools can support exploration, they cannot replace student-generated questions and ideation. Learners should be encouraged to pose original problems and investigate multiple solutions. Integrating AI into inquiry-based learning can enhance students' ability to formulate effective prompts and engage in deeper exploration.

5. Application and Innovation

Students can use AI tools to design, create, and solve complex problems. This includes engaging in collaborative project-based learning, real-world simulations, and digital storytelling. AI applications in education are transforming classrooms by enabling personalized learning experiences and fostering innovation.

6. Reflective Thinking

Reflecting on what they learn, how they learn, and how to improve is essential for students. AI tools can enhance reflective practices by providing prompts that encourage deeper introspection and by analyzing reflections to identify themes and insights.

For instance, to fully benefit from AI tools like ChatGPT while avoiding its limitations, it is suggested that learners be guided by significant deep learning principles as shown in the following table.

Deep Learning Competencies and Applications with ChatGPT

Deep Learning Competency	Application with ChatGPT
Critical Thinking	Questioning ChatGPT responses, comparing multiple sources
Knowledge Integration	Synthesizing ChatGPT output with classroom material
Self-regulated Learning	Setting learning goals and using ChatGPT to achieve them
Creative Inquiry	Using ChatGPT to brainstorm, simulate dialogue, or model ideas
Ethical Reasoning	Reflecting on the social impact of AI-generated content
Reflective Thinking	Evaluating the effectiveness and limitations of ChatGPT use

Pedagogical Implications and Recommendations

The shift toward deep learning in the AI era requires systemic changes at multiple levels of the education system. First, curricula should be redesigned to emphasize inquiry-based learning, interdisciplinary problem-solving, and real-world relevance. These elements foster the depth of understanding and skill transfer that are hallmarks of deep learning [3].

Second, AI literacy should be introduced as part of the core curriculum. Students need to understand how AI systems work, their limitations, ethical concerns (e.g., bias, surveillance), and their societal implications [11]. This empowers learners to use AI responsibly and critically.

Third, assessment practices should evolve. Traditional tests that measure recall must be replaced or supplemented by performance-based assessments, portfolios, and collaborative projects. These approaches provide more valid indicators of students' ability to think critically, solve problems, and work creatively.

Fourth, teacher professional development must support the transition to deep learning pedagogies. Teachers need opportunities to engage with AI tools, reflect on their teaching practices, and collaborate in redesigning instruction for depth and relevance [12].

Finally, schools must cultivate a culture of continuous learning, inquiry, and reflection for both students and educators. Only then can AI be harnessed to enhance, rather than diminish, the human experience of learning.

As an example, recognizing the transformative potential of AI in education, the U.S. government and several states have recently advanced strategic initiatives to guide AI integration in K–12 education. In April 2025, the federal government issued an executive order titled Advancing Artificial Intelligence Education for American Youth [13]. This aims to promote foundational and applied AI literacy among students, provide sustained AI training for teachers and school administrators, and support curriculum development with age-appropriate AI concepts integrated across disciplines.

In practice, pilot programs have been implemented in school districts across California, Texas, and Massachusetts. For instance, California's "AI Learning Pathways" initiative introduces middle schoolers to ethical AI use and data literacy, while high school students explore machine learning applications in STEM coursework. These programs also involve partnerships with tech companies and universities to provide resources and teacher support. At the state level, frameworks are emerging to ensure that AI integration aligns with broader educational goals. Common elements include ethical and equitable access to AI resources, development of standards for digital and AI literacy, and investment in teacher professional development. Such coordinated efforts underscore the importance of equipping young learners with future-ready skills and ensuring AI is used to empower human-centered learning.

III. Conclusion

As AI continues to reshape the world, education must respond by equipping young learners with the skills, mindsets, and capacities that will enable them to cope with new challenges. Deep learning provides a powerful framework for this transformation. It nurtures the human strengths that AI cannot replicate, which include critical thought, ethical judgment, creative problem-solving, and emotional insight. It transforms students from passive recipients into active agents of their own learning and of change in the wider world. The imperative is obvious that we want students to thrive in an AI-driven future, we must teach them how to learn deeply, think

broadly, and act wisely. It requires systemic commitment from policymakers, curriculum developers, teacher educators, and community stakeholders. We must build infrastructures that support deep learning practices, integrate AI ethically and meaningfully into curricula, and prioritize equitable access to AI-enhanced education. Moreover, the role of teachers will become increasingly critical. Teachers are no longer dispensers of knowledge, but facilitators of inquiry and designers of meaningful learning experiences in immensely technology-assisted learning environments. Therefore, schools must become ecosystems of innovation where technology and pedagogy align to empower every child. In brief, preparing school children to thrive in the AI era is central to safeguarding our democratic values, advancing social equity, and shaping a future in which humanity and technology coexist constructively.

References

[1] Marton, F., & Säljö, R. (1976). On Qualitative Differences In Learning: Outcome And Process. British Journal Of Educational Psychology, 46(1), 4–11.
[2] Biggs, J., & Tang, C. (2011). Teaching For Quality Learning At University (4th Ed.). Open University Press.
[3] Fullan, M., Quinn, J., & Mceachen, J. (2018). Deep Learning: Engage The World, Change The World. Corwin Press.
[4] Bransford, J. D., Brown, A. L., & Cocking, R. R. (Eds.). (2000). How People Learn: Brain, Mind, Experience, And School. National Academy Press.
[5] Do, T. M. T., Doan, T. H. D., & Do, M. C. (2020). Deep Learning For Higher Education Students Phương Thức Học Cần Có Cho Sinh Viên Ở Bậc Đại Học. Tạp Chí Khoa Học Giáo Dục Việt Nam, 64(4), 51–60.
[6] Selwyn, N. (2019). Should Robots Replace Teachers? AI And The Future Of Education. Polity Press.
[7] Facione, P. A. (2011). Critical Thinking: What It Is And Why It Counts (2011 Update). Insight Assessment.
[8] Zimmerman, B. J. (2002). Becoming A Self-Regulated Learner: An Overview. Theory Into Practice, 41(2), 64–70. Https://Www.Tandfonline.Com/Doi/Abs/10.1207/S15430421tip4102_2
[9] Siemens, G., & Long, P. (2011). Penetrating The Fog: Analytics In Learning And Education. EDUCAUSE Review, 46(5), 30–32.
[10] Jin, S., Im, K., Yoo, M., Roll, I., & Seo, K. (2023). Supporting Students' Self-Regulated Learning In Online Learning Using Artificial Intelligence Applications. International Journal Of Educational Technology In Higher Education, 20(1), Article 37.
[11] Perrotta, C., & Selwyn, N. (2020). Deep Learning Goes To School: Toward A Relational Understanding Of AI In Education. Learning, Media And Technology, 45(3), 251–269. Https://Doi.Org/10.1080/17439884.2020.1686017.
[12] Nguyen, N.Q. (2022) Postlesson Affordance-Based Reflective Discussion In ELT Classes. TESOL Journal Https://Doi.Org/10.1002/Tesj.677.
[13] The White House. Executive Orders. April 23, 2025. Advancing Artificial Intelligence Education For American Youth.H