

Rethinking Education in the AI Era: Balancing Factual Understanding and AI Support for Future-Ready Learning

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Abstract:

The rapid integration of artificial intelligence (AI) in education has transformed traditional approaches to teaching and learning, raising critical questions about the balance between human cognition and technological support. This study rethinks education in the AI era by examining the interplay between factual understanding and AI support in fostering future-ready learning. Grounded in cognitive load theory and self-regulated learning perspectives, the paper proposes a conceptual framework in which factual understanding and AI support jointly influence learning outcomes, mediated by cognitive engagement and self-regulation. While AI enhances efficiency, accessibility, and personalized learning, excessive reliance may lead to superficial learning, reduced critical thinking, and diminished academic authenticity. Conversely, strong factual understanding enables learners to critically evaluate AI-generated information and engage in deeper learning processes. The study highlights the importance of achieving a balanced integration of human and artificial intelligence to promote meaningful and sustainable learning. The findings have significant implications for educators, policymakers, and curriculum designers, emphasizing the need to develop pedagogical strategies, AI literacy, and ethical guidelines that support responsible AI use. Ultimately, the paper contributes to the growing discourse on human–AI collaboration in education and offers a framework for preparing learners for an increasingly complex digital future.

Keywords: Artificial Intelligence (AI) in Education, AI Support, Factual Understanding, Future-Ready Learning, Self-Regulated Learning, Human-AI Interaction

1. Introduction

The rapid advancement of artificial intelligence (AI) fundamentally transformed contemporary educational landscapes by reshaping how knowledge is accessed, constructed and applied. In modern classrooms and online learning environments, AI-powered tools such as intelligent tutoring systems (Young, 2024), adaptive learning platforms (Kataria, 2023) and generative models have become integral to teaching and learning processes (Chetry, 2024). These tools enable learners to access information instantly, receive automated feedback, and engage in personalized learning experiences that transcend traditional pedagogical boundaries (Alam & Mohanty, 2023). However, alongside these technological advancements, critical questions have emerged regarding the nature of knowledge and the role of human cognition in an AI-mediated world. Traditionally, education has emphasized factual understanding, which involves the acquisition of conceptual knowledge, principles, and disciplinary content necessary for critical thinking and problem-solving (Visser et al., 2003; Yu et al., 2015). In contrast, the AI age introduces

AI-based support, in which learners rely more on artificial intelligence (AI) systems to produce, interpret and process information (Singh et al., 2025). Although this kind of assistance increases productivity and accessibility (Saar et al., 2025), it also raises questions around learning authenticity, higher-order thinking skills development and cognitive engagement (Fan et al., 2025).

Recent research highlights both the transformative potential and the challenges associated with AI integration in education. For instance, AI-mediated learning environments have been shown to improve engagement and provide personalized feedback tailored to individual learner needs (Yar & Sabzehparvar, 2025). Similarly, AI technologies facilitate access to authentic content and enable flexible learning opportunities that are not constrained by time or location (Derakhshan & Solhi, 2025). Despite these advantages, scholars have raised concerns about the risks of over-reliance on AI tools (Zhai et al., 2024), including diminished critical thinking, reduced self-efficacy and a decline in authentic learning experiences (Ofiaz, 2025). Moreover, students increasingly use AI tools to complete academic tasks without fully understanding the underlying concepts, leading to superficial learning and a disconnect between performance and knowledge acquisition (Sibarani, 2026). These developments indicate that the integration of AI in education is not merely a technological shift but a conceptual one that requires a fundamental rethinking of educational practices and priorities. In this context, there is a pressing need to examine how factual understanding and AI-based support can be effectively balanced to promote meaningful, authentic, and future-ready learning.

2. Changing Landscape of Education in the AI Era

2.1 Evolution of Education Systems

The landscape of education has undergone significant transformation over time, evolving from traditional teacher-centered models to digitally mediated and now AI-driven learning environments (Diyal & Pandey, 2025). In traditional education systems, learning was largely characterized by a one-way transmission of knowledge from teacher to student, with a strong emphasis on memorization, rote learning and standardized instruction. Knowledge was viewed as static and fixed, and students were expected to acquire and reproduce information rather than critically engage with it. This model, while effective in certain contexts, often limited opportunities for personalized learning and critical thinking, as it did not account for individual differences in learning styles, pace, or interests (Visser et al., 2003).

With the advent of information and communication technologies (ICT), education entered a new phase characterized by digital integration (Hutchison & Reinking, 2011). Digital education introduced tools such as computers, the internet and learning management systems, enabling more interactive and flexible learning experiences. However, despite these advancements, digital education largely remained content-driven, with technology serving as a medium for delivering information rather than fundamentally transforming the learning process (Alam & Mohanty, 2023).

The emergence of artificial intelligence marks a new stage in the evolution of education, characterized by personalization, automation and intelligent decision-making (Pedro et al., 2019). AI-driven education systems leverage advanced algorithms to analyze learner data, adapt instructional content provide real-time feedback. Tools such as adaptive learning platforms and intelligent tutoring systems can tailor learning experiences to individual needs, thereby enhancing engagement and learning outcomes (Kataria, 2023; Young, 2024). AI-driven education stresses learner-centered approaches, in which students actively engage with technology to construct knowledge, in contrast to traditional and digital education paradigms.

This change signifies a transition from standardized instruction to personalized learning paths, where education is now a dynamic and adaptable experience rather than a one-size-fits-all procedure.

2.2 Role of AI in Modern Classrooms

In today's classrooms, artificial intelligence is becoming more and more important, changing the way that teaching and learning procedures are planned and carried out. One of the most prominent applications of AI in education is the use of intelligent tutoring, which simulate one to one instruction by providing personalized guidance and feedback. These systems analyze learners' performance and adapt instructional strategies accordingly, helping students overcome learning difficulties and achieve better outcomes (Young, 2024). By offering individualized support, intelligent tutoring systems bridge gaps in traditional classroom settings, where teachers may not always have the capacity to address the needs of every student (Lin et al., 2023).

Another significant development is the rise of generative AI tools, which have gained extensive attention for their ability to produce human-like text, solve problems and generate explanations. These tools are increasingly used by students to assist with writing, research and problem-solving tasks, as well as by educators to design instructional materials and assessments (Chetry, 2024). Generative AI has the potential to enhance learning by providing instant access to information and facilitating deeper understanding through interactive dialogue. However, it also raises concerns about academic integrity and the authenticity of student work (Khatri & Karki, 2023), as learners may rely on AI-generated content without fully engaging with the material.

2.3 Opportunities and Challenges

The integration of AI in education presents numerous opportunities that have the potential to enhance learning experiences and outcomes. One of the most significant advantages is increased accessibility, as AI technologies enable learners to access educational resources anytime and anywhere. This is particularly beneficial for students in under-resourced or remote areas, who may otherwise face barriers to quality education (Derakhshan & Solhi, 2025). Additionally, AI supports personalized learning by adapting content to individual needs, allowing learners to progress at their own pace and receive targeted support. This personalization enhances learner engagement and motivation, as students are more likely to remain interested when learning experiences are tailored to their preferences and abilities (Yar & Sabzehparvar, 2025). AI tools can automate routine tasks such as grading, feedback and content generation, enabling educators to focus on more complex and meaningful aspects of teaching. Furthermore, AI can reduce cognitive load by providing structured guidance and simplifying complex tasks, allowing learners to focus on higher-order thinking processes (Sibarani, 2026). These benefits highlight the potential of AI to transform education into a more efficient, inclusive and learner-centered system.

However, alongside these opportunities, AI integration also presents significant challenges that must be addressed. One of the primary concerns is the risk of dependency, as learners may become overly reliant on AI tools for completing academic tasks (Alhur et al., 2025). This dependency can lead to reduced cognitive engagement and hinder the development of critical thinking and problem-solving skills (Zhai et al., 2024). Additionally, issues related to academic integrity and authenticity have emerged, as AI-generated content may not accurately reflect students' understanding or abilities (Ofiaz, 2025). This raises important questions about assessment practices and the validity of learning outcomes in AI-mediated environments.

Ethical considerations also play a crucial role in the integration of AI in education. Concerns about data privacy, algorithmic bias and fairness have been widely discussed in the literature, highlighting the need

for responsible and ethical use of AI technologies (Kim et al., 2026). Moreover, the digital divide remains a significant challenge, as unequal access to AI tools and resources can exacerbate existing educational inequalities. Students from under-resourced backgrounds may lack the infrastructure or training needed to effectively utilize AI technologies, leading to disparities in learning opportunities and outcomes (Wang et al., 2025).

In addition to cognitive and ethical challenges, AI-mediated learning environments can also impact learners' emotional and psychological well-being. While AI tools can enhance engagement and motivation, they may also contribute to stress, cognitive overload and feelings of isolation, particularly when learners rely heavily on technology without sufficient human interaction (Du & Yang, 2025). These challenges underscore the importance of adopting a balanced approach to AI integration that considers not only technological capabilities but also pedagogical, ethical and psychological dimensions.



Fig1. Balanced educational framework in the AI era

3. Conceptualizing Factual Understanding in AI-Based Education

Even in rapidly changing AI-mediated learning settings, factual information is essential to education. Internalizing conceptual knowledge, concepts and disciplinary material helps learners understand, interpret and apply information. Education has traditionally focused on factual comprehension and cognitive processes that allow reasoning and problem-solving (Visser et al., 2003). Thus, factual knowledge entails integrating concepts and ideas into consistent mental frames to improve comprehension, not only memory. Yu et al. (2015) underline that conceptual comprehension helps learners connect existing knowledge with new material for meaningful learning and long-term retention.

3.1 Importance in Learning

The importance of factual understanding in learning becomes even more pronounced in AI-mediated educational contexts, where learners are exposed to vast amounts of information generated by intelligent systems. One of the primary roles of factual understanding is to support critical thinking, which involves analyzing, evaluating and synthesizing information. Learners with strong conceptual knowledge are better equipped to question the accuracy and relevance of AI-generated content, thereby reducing the risk of misinformation. This is particularly important given that AI systems, while powerful are not infallible and may produce biased or inaccurate outputs (Kim et al., 2026). Furthermore, factual understanding facilitates knowledge transfer, enabling learners to apply learned concepts to novel situations and solve complex

problems. This ability is essential in the AI era, where learners must adapt to rapidly changing information landscapes and utilize both human cognition and technological tools effectively.

3.2 Risks of Decline

Despite its importance, factual understanding is increasingly threatened in AI-supported learning environments, particularly through the rise of surface learning, where learners prioritize quick answers over conceptual comprehension. The ease of AI-generated responses encourages reduced cognitive effort and shallow engagement, undermining critical thinking and problem-solving skills (Zhai et al., 2024). Additionally, excessive reliance on AI diminishes cognitive engagement, motivation and self-regulation, negatively affecting learners' self-efficacy and meaningful learning (Oflaz, 2025). Furthermore, AI use raises concerns about academic authenticity, as students may complete tasks without genuine understanding, creating a gap between performance and knowledge acquisition (Sibarani, 2026).

4. Understanding AI Support in Education

4.1 Concept of AI Support

AI support in education refers to the use of artificial intelligence systems to assist learners in accessing, processing and applying information. These systems leverage advanced algorithms to provide personalized learning experiences, automate feedback, and enhance instructional efficiency. AI support can be understood as a form of algorithmic assistance that extends human cognitive capabilities, enabling learners to perform tasks more effectively and efficiently (Singh et al., 2025). In educational contexts, AI support functions as a cognitive partner, guiding learners through complex tasks and providing real-time assistance.

4.2 Forms of AI Support

AI support manifests in various forms within educational environments, each contributing to different aspects of learning. Generative AI tools (e.g. chatbots and language models) are among the most widely used applications, enabling learners to generate content, solve problems and receive explanations in real time (Chetry, 2024). These tools facilitate interactive learning experiences and provide immediate access to information, making them valuable resources for both students and educators. Additionally, automated feedback systems play a crucial role in AI-supported learning by providing instant evaluation and suggestions for improvement, thereby enhancing learning efficiency and engagement (Yar & Sabzehparvar, 2025). AI-supported personalized learning systems leverage data analytics to customize instructional content for each student. Adaptive learning platforms track learners' progress, identify areas of difficulty and change content to support them at each stage (Kataria, 2023). These technologies encourage personalized learning and address varied learning requirements, making education more accessible and effective.

4.3 Enhancing Learning Through AI Support

The integration of AI support in education offers several benefits that contribute to enhanced learning experiences. Increased efficiency is one of the main benefits, since AI systems automate repetitive procedures like material creation, grading and feedback, freeing up students and teachers to concentrate on higher-order cognitive functions. Furthermore, AI improves accessibility by giving students access to learning materials at any time or place, fostering inclusive learning environments (Derakhshan & Solhi, 2025). Another significant benefit is the reduction of cognitive load, as AI systems simplify complex tasks and provide structured guidance, enabling learners to process information more effectively (Sibarani, 2026).

4.4 Risks and Limitations

Despite its advantages, AI support in education also presents several risks and limitations that must be carefully considered. One of the most significant challenges is over-dependence, as learners may rely excessively on AI tools for completing academic tasks, leading to reduced cognitive engagement and diminished critical thinking skills (Zhai et al., 2024). Additionally, issues related to academic integrity have emerged, as AI-generated content may not accurately reflect learners' understanding or abilities (Oflaz, 2025). Concerns about bias and inaccuracies in AI systems further complicate their use, as these technologies may produce misleading or incomplete information (Kim et al., 2026). These limitations highlight the need for a balanced approach that integrates AI support with strong foundational knowledge, ensuring that technology enhances rather than undermines the learning process.

5. The Need for Balance: Integrating Factual Understanding and AI Support

In AI-mediated education, balancing factual understanding and AI support is essential for meaningful learning. Rather than equal emphasis, this balance reflects a complementary relationship where factual knowledge enables critical evaluation and AI enhances efficiency and accessibility. When used appropriately, AI augments rather than replaces human cognition, promoting deeper engagement and active learning (Sibarani, 2026; Zhai et al., 2024).

5.1 Models of Integration

Achieving this balance requires the adoption of effective models of integration that align human cognition with technological support. One such model is human-AI collaboration, where learners interact with AI systems as cognitive partners. In this approach, AI assists in generating ideas, providing feedback and offering explanations, while learners critically evaluate and refine these outputs using their own knowledge. This interaction promotes deeper engagement and fosters critical thinking skills. Another important model is guided AI use, where educators play a central role in structuring how AI tools are incorporated into learning activities (Choi et al., 2026). Teachers guide students in using AI responsibly, encouraging them to verify information, reflect on outputs and integrate AI-generated content with their own understanding. Such guided approaches ensure that AI enhances learning without undermining cognitive development, thereby supporting a balanced and pedagogically sound integration.

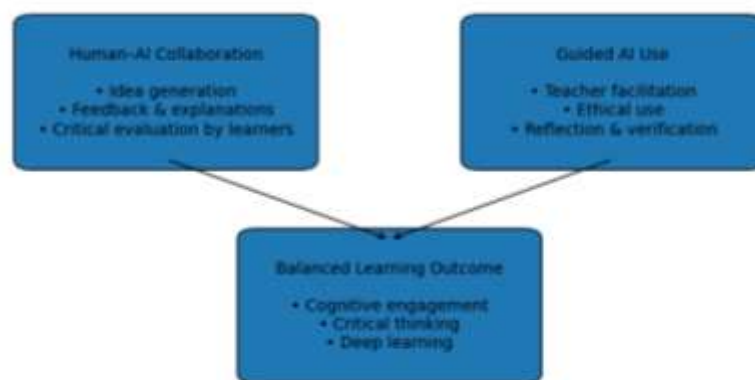


Fig2. Model of Integrating AI Support for Balanced Learning Outcomes

5.2 Risks of Imbalance

While AI integration offers clear benefits, an imbalance between factual understanding and AI support can hinder learning outcomes. Over-reliance on AI may lead to shallow learning, reduced cognitive effort and

weakened critical thinking and problem-solving skills (Zhai et al., 2024). Conversely, limited use of AI can restrict the development of essential digital and technological competencies required in modern contexts (Sibarani, 2026). Both extremes over-dependence and underutilization negatively affect learning effectiveness. Therefore, a balanced approach that integrates human cognition with AI support is essential for fostering meaningful, future-ready learning (Oflaz, 2025).

6. Future-Ready Learning in the AI Era

Future-ready learning involves developing skills and competencies that enable learners to adapt to a rapidly evolving technological landscape. In the AI era, it extends beyond traditional knowledge to include critical thinking, problem-solving and effective interaction with intelligent systems. It emphasizes adaptability, creativity and lifelong learning, preparing individuals to navigate the complexities of the digital world (Mutlu, 2025; Sibarani, 2026).

6.1 Key Competencies

The development of future-ready learning requires a focus on key competencies that are essential for success in the AI-driven world. Critical thinking is fundamental, as it enables learners to analyze information, evaluate arguments and make informed decisions. AI literacy is equally important as it involves understanding how AI systems function, recognizing their limitations and using them responsibly. Digital literacy supports learners in navigating digital environments, accessing information, and communicating effectively using technology.

6.2 Role of Balanced Learning

A balanced approach to integrating factual understanding and AI support plays a vital role in fostering future-ready learning. By combining strong conceptual knowledge with effective use of AI tools, learners develop both cognitive depth and technological competence. This balance enhances adaptability, enabling individuals to respond to changing circumstances and evolving technologies. Furthermore, it promotes lifelong learning by encouraging continuous engagement with new knowledge and skills. Ultimately, balanced learning ensures that learners are not only proficient in using AI but also capable of thinking critically, acting ethically and contributing meaningfully in an increasingly complex and interconnected world.

7. Psychological and Emotional Dimensions of AI-Supported Education

The integration of AI in education influences both cognitive and emotional dimensions of learning. AI tools reduce cognitive load by simplifying tasks and providing instant feedback, improving learning efficiency (Sibarani, 2026). However, over-reliance can lead to cognitive offloading, limiting critical thinking and deep understanding. AI also affects emotional experiences, as personalized feedback can enhance motivation and engagement (Yar & Sabzehparvar, 2025), while excessive dependence may increase stress and reduce self-efficacy (Oflaz, 2025). In this context, emotional intelligence is essential, as it helps learners regulate emotions, stay motivated and critically evaluate AI outputs. Learners with higher emotional intelligence engage more effectively with AI tools, leading to improved learning outcomes (Wang & Du, 2026).

Table 1. Psychological and Emotional Benefits and Risks of AI-Supported Education

Dimension	Benefits	Risks
Cognitive	Reduces cognitive load, improves efficiency	Cognitive offloading, shallow learning
Emotional	Enhances motivation and engagement	Stress, dependency, reduced self-efficacy
Academic	Personalized learning, instant feedback	Academic integrity issues
Ethical	Supports inclusive learning	Bias, privacy concerns

8. Conceptual Framework of interaction between factual understanding and AI support

The conceptual framework emphasizes the interaction between factual understanding and AI support as key inputs in AI-mediated education. Factual understanding represents the learner’s internal knowledge base, while AI support provides external technological assistance. These inputs are mediated by self-regulated learning and cognitive engagement, which influence how learners interact with both knowledge and technology. Self-regulated learning enables learners to plan, monitor and evaluate their learning processes, while cognitive engagement ensures active involvement in learning tasks. Together, these factors contribute to the development of future-ready learning outcomes, including critical thinking, adaptability and problem-solving skills. This framework highlights the importance of balancing human cognition and AI support for effective learning.

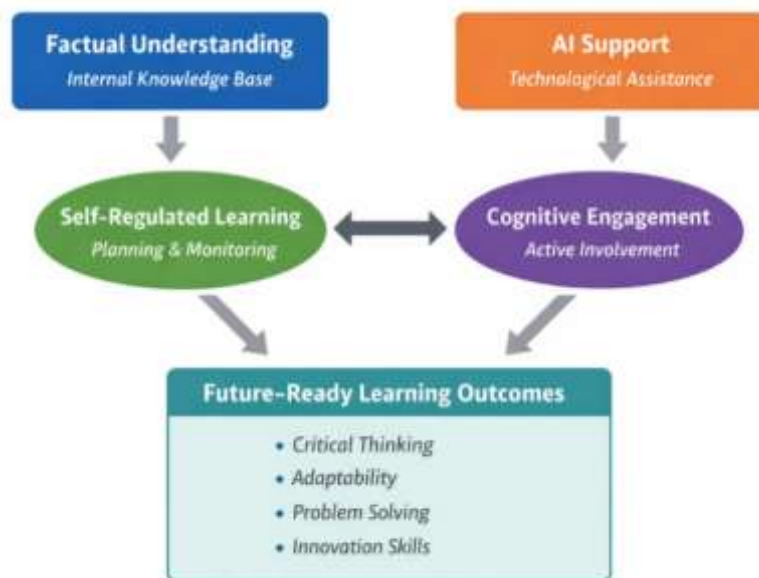


Fig 3. Framework of interaction between factual understanding and AI support

9. Implications for Education

9.1 Pedagogical Implications

The integration of AI in education necessitates a shift in pedagogical practices, emphasizing the balance between factual understanding and AI support. Curriculum design should incorporate AI tools while maintaining a strong focus on conceptual learning and critical thinking. Teaching strategies must encourage active learning, reflection, and critical evaluation of AI-generated content. Educators should

create learning environments that promote meaningful engagement with both knowledge and technology, ensuring that AI enhances rather than replaces cognitive processes.

9.2 Teacher Education

Teacher education plays a vital role in the effective integration of AI in education. Educators must develop AI literacy, enabling them to understand and use AI tools effectively in teaching and learning contexts. Professional development programs should focus on equipping teachers with the skills needed to guide students in responsible AI use, foster critical thinking and integrate AI into pedagogical practices. This will help teachers adapt to the evolving educational landscape and support students in becoming future-ready learners (Mutlu, 2025).

9.3 Policy Implications

The integration of AI in education requires the development of clear policies and guidelines to ensure ethical and equitable use. Policymakers must address issues related to academic integrity, data privacy, and algorithmic bias to protect learners and maintain the quality of education. Additionally, efforts should be made to ensure equitable access to AI technologies, reducing the digital divide and promoting inclusive learning environments. Effective policies will support the responsible integration of AI and enhance its benefits in education.

10. Conclusion

The integration of artificial intelligence in education marks a significant shift in how teaching and learning are conceptualized and practiced. This paper has argued that while AI offers substantial benefits in terms of efficiency, accessibility, and personalization, it also introduces challenges that necessitate a fundamental rethinking of education. Central to this discussion is the need to balance factual understanding with AI support to ensure meaningful and effective learning outcomes. Factual understanding remains essential as it provides the cognitive foundation for critical thinking, problem-solving and the evaluation of information, while AI support enhances learning by offering adaptive, responsive and efficient tools.

However, the findings highlight that over-reliance on AI can lead to shallow learning, reduced cognitive engagement and diminished academic authenticity, whereas insufficient use of AI may limit learners' ability to develop essential digital competencies. Therefore, a balanced approach that integrates human cognition with technological support is crucial. The proposed conceptual framework emphasizes the role of self-regulated learning and cognitive engagement as mediating factors that enable learners to effectively combine factual knowledge with AI capabilities.

Furthermore, the study underscores the importance of fostering AI literacy, emotional intelligence and ethical awareness to support responsible and effective AI use. Educators, policymakers, and institutions must collaborate to design pedagogical strategies and policies that promote this balance. Ultimately, the future of education lies not in replacing human intelligence with artificial intelligence, but in creating a synergistic relationship where both coexist to enhance learning, empower learners, and prepare them for the complexities of an AI-driven world.

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