# AI Agents in Education: An Early Systematic Review of Emerging Roles, Potential, and Limitations

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**Abstract**: In a world where ChatGPT writes essays and solves math problems in seconds, an important question emerges: who will shape the character and values of the next generation – cold and precise algorithms or teachers who understand the needs, potential, and sensitivity of human beings?

Recent advances in artificial intelligence, particularly the emergence of sophisticated AI agents like ChatGPT, have sparked intense debate about their role in education. While these technologies promise to transform teaching and learning processes, their rapid evolution and widespread adoption have outpaced our understanding of their implications.

This scoping review addresses a critical gap in current literature by systematically examining the potential, limitations, and challenges of integrating AI agents in educational settings. The review is particularly timely given the accelerated digitalization of education following the global pandemic and the subsequent proliferation of AI tools in classrooms. By synthesizing emerging research and empirical evidence, this study provides educators, policymakers, and researchers with a comprehensive framework for understanding how AI agents can effectively complement, rather than replace, traditional teaching methods.

Our analysis explores key dimensions including: the typology and functionalities of educational AI agents; their impact on student engagement and learning outcomes; their limitations in developing higher-order cognitive skills and social-emotional competencies; and the evolving role of teachers in AI-enhanced learning environments. This systematic examination helps identify research gaps, inform evidence-based implementation strategies, and guide future investigations into the long-term effects of AI integration in education.

The findings underscore the need for a balanced, nuanced approach to incorporating AI agents in educational practice, while highlighting critical areas requiring further research and development. This review contributes to the growing body of knowledge essential for developing effective policies and practices that maximize the benefits of AI in education while preserving the irreplaceable human elements of teaching and learning.

**Keywords**: AI agents, artificial intelligence in education, AIED, digital technologies, digitalisation of education, AI integration, innovative pedagogies

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# 1. Introduction and Background

An **artificial intelligence agent** (AI agent) is a software entity that acts similarly to a human. Its role is to perform many of the tasks of a "user", acting autonomously. It has the ability to learn, memorize, independently perform specific tasks, make decisions, and interact with both its environment and other AI agents. An AI agent is not programmed to simply follow a predefined set of rules but has memory and can leverage the knowledge of a large language model, as well as various tools, to decide and perform assigned tasks. Other definitions emphasize that AI agents are systems that can pursue complex goals without explicit training, operate in complex environments, be guided by natural language, and act autonomously without supervision, having the ability to use tools such as Internet search or scheduling and being able to plan actions.

AI agents differ from chatbots in that they are not limited to simple conversational interaction but incorporate a broader spectrum of functionality, including autonomous decision-making, learning, and planning. This distinction is essential for understanding their potential in various fields of application, including education.

**Educational AI agents** are software systems that can interact with students in a personalized way, providing learning support, answering questions, and facilitating educational activities (Zawacki-Richter et al., 2019). The pandemic context of 2020-2022 accelerated the adoption of digital technologies in education and highlighted both the opportunities and challenges of digitizing the educational process. In this context, AI agents have begun to be experimentally implemented in various educational contexts, from personalized tutoring systems to virtual assistants for teachers (Dziubaniuk et al., 2023).

The development of these technologies raises several key questions regarding the role of teachers in the digital age and the potential of artificial intelligence to assume certain pedagogical functions, roles, and tasks:

- To what extent can AI agents substitute for or complement teachers in didactic activities? This fundamental question addresses both the potential and limitations of technology in relation to the human dimension of education.

- What are the effects of AI agents on students' cognitive and metacognitive processes? This question is particularly important for the long term, as it concerns the impact on future generations' critical thinking, creativity, and capacity for self-reflection.

- How can we optimize the interaction between teachers and AI agents to maximize pedagogical benefits? This question aims to identify effective models of human-machine collaboration in educational settings.

- How can we maintain an appropriate balance between human interaction and AI assistance in the educational process? This question seeks to identify optimal models of technology integration while preserving the relational dimension of education.

- What are the ethical implications of integrating AI agents into education, particularly regarding equity and access? This question addresses the social and moral aspects of using technology in education.

- How effectively can AI agents provide personalized feedback and assess students' skills with validity and reliability? This explores the potential and limitations of AI in educational assessment.

- What skills do teachers need to effectively integrate AI agents into their teaching? This question concerns the necessary changes in professional development as education becomes increasingly digitized.

Despite their potential, AI agents have significant limitations that prevent them from completely replacing teachers. Research indicates difficulties in developing students' social-emotional skills, limitations in adapting to unforeseen situations, and challenges in maintaining long-term motivation (Rienties et al., 2023). Major concerns that are only beginning to be explicitly outlined include the accuracy of generated information, potential biases, and lack of human empathy.

Analysis of current literature and experiences suggests that AI agents represent valuable tools for enhancing and streamlining the educational process, but they cannot fully replace the complex role of teachers.

## 2. The Conceptual Framework

The theoretical foundation for using AI agents in education rests on several conceptual frameworks. The TPACK (Technological Pedagogical Content Knowledge) model provides a useful perspective for understanding how technology can be effectively integrated into the educational process. This model highlights the need to blend content knowledge, pedagogical expertise, and technological understanding for effective teaching (Koehler & Mishra, 2008).

Bloom's taxonomy provides another relevant theoretical framework for evaluating how AI agents can develop different cognitive levels. Research shows that AI agents effectively support skill development at the taxonomy's lower levels — recall, understanding, and application—but struggle to facilitate higher-level skills such as analysis, synthesis/evaluation, and creation (Al Ghazali et al., 2024).

From the perspective of learning theories, AI agents can be analyzed through constructivism and social learning theory. Their ability to facilitate personalized learning and provide immediate feedback aligns with constructivist principles, while their limitations in facilitating authentic social interactions present challenges from the perspective of social learning theory (Dziubaniuk & Nyholm, 2020).

## 3. Typology and Functionalities of AI Agents in Education

The literature outlines several main categories of AI agents used in education, each with specific functionalities and applications. Models such as ChatGPT represent a new generation of conversational agents that can naturally interact with users and generate content adapted to educational contexts (MacNeil et al., 2022). These agents can provide round-the-clock support by answering students' questions in real time (ElSayary, 2024) and can tailor the learning experience to each student's pace and style. Studies show that AI agents can increase student participation and facilitate critical thinking development through structured interactions (Al Ghazali et al., 2024).

Broadly speaking, educational AI agents fall into three functional categories, which may overlap:

- Intelligent tutoring systems (or educational chatbots) that provide students with personalized assistance through conversational interactions
- Specialized assessment agents that support both students and teachers in tracking academic progress
- Virtual teaching assistants that help teachers design learning activities and manage classrooms

The first major category comprises **intelligent tutoring systems**. These systems use advanced algorithms to provide personalized instruction and adaptive feedback, identifying learning gaps and adjusting educational content in real time to meet individual student needs (D'Mello & Graesser, 2023). They are particularly effective in supporting comprehension by clarifying concepts and relationships between them, while providing adaptive learning support.

The second category includes **assessment and evaluation agents**. These can analyse student responses, provide immediate feedback, and generate detailed progress reports. Research shows that while these agents can significantly improve assessment efficiency, achieving accuracy and depth in feedback remains challenging (Wilichowski & Cono, 2023).

The third category consists of **virtual assistants for lesson planning and teaching management**. These agents can develop lesson plans, teaching materials, and assessments, significantly reducing teachers' administrative workload. For example, ChatGPT can quickly generate educational resources tailored to different learning levels and cognitive styles (ElSayary, 2024). Another relevant example is AIDA (AI Digital Assistant), which can develop teaching materials, evaluate student responses, and provide personalized feedback (Bond et al., 2024b).

These agents can function either independently or in an integrated manner, forming complex educational ecosystems that support both teaching and learning.

Based on analysis of current educational needs and trends, we anticipate the development of these main types of AI educational agents:

- Tutorial agents that provide individualized assistance to students throughout the learning process by explaining concepts, answering questions, and guiding problem-solving. For example, the Khanmigo system can engage in dialogue with students and help them understand mathematical concepts step by step. Similarly, Character AI can support specialized dialogues on various scientific topics.

- Assessment agents that analyse student performance, provide feedback, and generate personalized assessments. Examples include systems that can automatically grade essays or generate assessment questions tailored to individual student levels.

- Academic counselling agents that support students in making educational decisions by providing recommendations for course selection and career planning. One example is EASElective, which facilitates course selection discussions.

- Collaboration agents that facilitate student interaction and teamwork by moderating discussions and coordinating group projects. Examples include chatbots that can moderate discussion forums and coordinate collaborative activities.

- Instructional design/ planning agents that assist teachers in designing lessons, generating instructional materials, and organizing content. For example, ChatGPT can generate personalized lesson plans and suggest differentiated activities for various learning styles.

- Teaching assistants that handle administrative and organizational tasks, allowing teachers to focus on instruction. For example, AI systems can automate attendance tracking and prepare academic progress reports.

- Subject-specific agents that provide specialized support in areas such as science, languages, or programming. An example is the MineDojo system for learning programming through the Minecraft game.

The subject-specific category shows particular potential for supplementing traditional instruction, especially at the secondary and high school levels:

- For Mathematics and Science – agents that can explain step-by-step problem-solving, prove theorems, generate custom exercises, and visualize abstract concepts. The ELLA-V system, for example, provides detailed explanations for each calculation step and adapts its level of explanation.

- For Chemistry – agents specializing in molecular modelling, simulating chemical reactions, and explaining substance properties. For example, agents that can generate and analyse 3D molecular structures to help students better understand chemical bonds.

- For Foreign Languages – conversational agents that facilitate dialogue practice, correct pronunciation, provide grammar exercises, and support vocabulary learning. Systems can adapt conversations to students' language levels and provide contextualized feedback (e.g., Duolingo Video Call and Duolingo Max).

- For Programming – agents that assist in writing code, debugging, and learning programming concepts. MineDojo exemplifies this by using the Minecraft environment to teach programming interactively.

- For Humanities – agents specializing in textual analysis, generating sample essays, and facilitating critical discussions. These agents can help develop argumentation and literary analysis skills.

- For Arts – agents that demonstrate artistic techniques, analyse compositions, and provide feedback on student work. These systems can generate examples in different artistic styles and explain design principles.

- For Physical Education – agents that analyse movement and technique, providing feedback to improve performance. They can use video processing to identify and correct technical mistakes.

- For Music – agents that teach music theory, analyse compositions, and assist in performance practice. These systems can break down musical pieces into their component elements, assess performances, and identify errors in rhythm or tonality.

## 4. The Impact and Effectiveness of AI Agents in the Educational Process: Limits and Challenges

The few existing empirical studies examining AI agents' impact in education reveal both significant benefits and important limitations.

A recent study at the upper secondary level demonstrated that using an AI agent to teach chemistry produced results comparable to traditional methods in knowledge and application domains, with significant advantages in reasoning for the experimental group using AI for learning (Al Ghazali et al., 2024).

In terms of student engagement, research indicates that AI agents can increase motivation in the short term through personalized interactions and immediate feedback. However, maintaining this engagement long-term proves challenging, especially without direct human interaction (Hong, 2023; Al Ghazali et al., 2024).

Learning personalization represents one of AI agents' most promising benefits. Their ability to adapt content and pace to individual student needs can significantly improve educational outcomes. Studies show that students with special educational needs particularly benefit from this customization (Iniesto & Bossu, 2023).

One significant challenge lies in developing social-emotional skills. Although AI agents can simulate empathy and emotional support, students perceive these interactions as artificial and insufficient for complete social-emotional development (Rienties et al., 2023).

Another major challenge concerns the accuracy and reliability of AI-generated information. The phenomenon of "AI hallucinations", where systems generate incorrect or inconsistent information, raises serious concerns in educational contexts. Research indicates the need for continuous human supervision to ensure content quality and accuracy (Lee & Soylu, 2023).

Regarding evaluation and feedback, AI agents show limitations in assessing complex responses requiring critical thinking and creativity. Recent research demonstrates that while they can effectively evaluate factual answers and simple applications, AI agents struggle to assess reasoning and original thinking (Halaweh, 2023).

Future perspectives suggest an evolution toward hybrid educational models where AI agents complement and augment teachers' roles. Future research should focus on:

- Developing more robust models for integrating AI agents into educational processes
- Enhancing evaluation and feedback capabilities for higher-order cognitive skills
- Exploring ways to support social-emotional development through AI agents
- Investigating the long-term impact of AI agents in education

## Conclusions

Analysis of specialized literature unanimously indicates that AI agents currently cannot fully replace teachers' complex roles in education. However, they serve as valuable tools that can significantly enhance certain aspects of teaching and learning.

Although AI agents demonstrate impressive capabilities in specific educational areas, the complexity of pedagogy requires a nuanced approach to technology integration. Education appears to be moving toward a hybrid model where technology and human factors complement each other to optimize learning experiences. The optimal approach involves integrating these technologies as complementary tools, enabling teachers to focus on qualitative aspects and activities requiring direct human interaction.

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