Learning Environment, Learning Outcomes and Artificial Intelligence: The Synergistic Relationship

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ABSTRACT

Artificial intelligence (AI) is reshaping the educational landscape by turning traditional classrooms into interactive, flexible, and personalised learning settings. This meta-analysis examines the incorporation of AI in education, highlighting its impact on learning environment and learning outcomes. It examines how AI technologies, via personalized learning pathways, smart tutoring systems, and immediate feedback, assist educators in delivering instruction suited to students' unique needs, preferences, and learning styles. Using environmental and pedagogical frameworks, the study explores the diverse effects of AI on essential aspects of the learning environment such as cognitive, emotional, physical, psychosocial and educational aspects. It shows that AI-powered tools enhance engagement and motivation while fostering equity and inclusion by adapting to different learner abilities. The study also shows how AI facilitates the simplification of administrative responsibilities like grading and data management, allowing teachers to focus on more significant student interactions throughout the learning process. There is a significant relationship between AI-powered learning settings and better educational results, underpinned by theoretical perspectives from Bandura's social cognitive theory. As students' behaviours and interactions with AI change, so do the results of their educational experiences. Novelty and innovations are essential for sustaining learner engagement when utilizing AI. The use of AI in education enables a transition from content-focused teaching to student-centred learning, resulting in more engaging, efficient and inclusive educational experiences. Educators are advised to adopt new technologies such as AI, AR and VR to address the requirements of 21st century students and enhance learning outcomes in an evolving learning environment.

Keywords: Learning environment, Artificial Intelligence, Learning outcomes

INTRODUCTION

Artificial intelligence (AI) has developed into a significant and transformative power that impacts numerous sectors and changes human habits and business functions. AI has the potential to transform traditional education and create a new era of personalized learning experiences (*Using AI in Education to Help Teachers and Their Students*, 2025). This study focuses on how AI is used in education and its significant role in enhancing learning experiences and improving outcomes, contrasting with the traditional focus on syllabus coverage in many schools. This discussion aims to illustrate how AI has been used to improve education, especially in improving students' learning experiences over time (Xu, 2024).

The learning environment and learning outcomes are fundamental concepts in educational research. A supportive learning environment, whether physical, psychological, or technological, fosters conditions where learners can thrive (Fraser, 2015). Learning outcomes represent the cognitive, affective, and skill-based changes that occur due to educational experiences (Biggs & Tang, 2011). With the rapid rise of AI in education, researchers are increasingly viewing AI as a powerful force that can reshape both learning environment and outcomes (Luckin et al., 2016).

Using AI, teachers can gain valuable insights into students' learning habits, preferences, and strengths, allowing them to customise instruction to meet individual needs. Personalised learning, made possible by AI, ensures that

students receive content and learning experiences tailored to their own learning styles, abilities, and interests. This approach encourages greater engagement with material, enhancing students' motivation and enthusiasm for learning.

AI is being integrated into education for various purposes. First, it aims to improve outcomes by offering personalized learning paths that adjust according to students' progress and understanding. AI systems continually assess students' knowledge and skills, allowing educators to identify areas needing more support for focused interventions. Second, AI improves teaching efficiency by automating administrative activities, such as grading and data management, so teachers can focus on building meaningful interactions with students. Third, AI supports inclusive learning by adapting to different learning speeds and abilities, ensuring that all students can succeed. Furthermore, AI promotes lifelong learning by offering personalized recommendations for ongoing skill development. By incorporating AI into education, students can take charge of their learning experiences while allowing teachers to guide their knowledge.

As AI technologies advance and become more sophisticated, their potential to revolutionize education continues to grow. Consequently, AI in education can change teaching methods and learning processes. The shift toward personalized learning experiences, facilitated by AI, is likely to increase student engagement, motivation, and academic performance. With AI technology, educational institutions can create adaptable, efficient, and inclusive learning environments that maximize each student's potential, transforming the pursuit of knowledge into an empowering experience (Deri, et al 2024).

Learning environment

The learning environment is where students feel motivated and comfortable to learn. A stimulus field consists of triggers that evoke responses from learners, facilitating learning and possibly resulting in changes in behavior; the field refers to the surroundings that accommodate these triggers. Stimuli are things in the environment that can provoke responses and affect behavior. The learning process involves learners reacting to stimuli within this field. Learning theorists focus on the learner and their environment, emphasizing the relationship between the learner and the stimuli they respond to (Olson & Ramírez, 2020).

A safe educational setting is crucial for students' intellectual and personal growth (Sayfulloevna, 2023). When creating a learning environment, it is essential to consider all factors that affect student development. The physical, cognitive, and emotional aspects should all be taken into account (Thompson & Wheeler, 2010). Educators have the responsibility to nurture an atmosphere where learners feel secure and empowered to explore and innovate.

When a learning environment does not meet students' needs, it creates discomfort for both students and teachers and fails to support learning (Thompson & Wheeler, 2010). Teaching and learning have often been separated from the physical space, but physical factors significantly affect learning outcomes (Guney & Al, 2012). Therefore, the importance of the learning environment on students' academic performance cannot be overstated. Research (Cayubit, (2022); Li, & Xue, (2023); Rusticus, *et al* (2023); Nguyen, *et al* (2022); Cheung, *et al* (2021) has shown that various characteristics of the learning environment impact the educational experience. These include:

Intellectual dimension

This aspect of a learning environment emphasizes deep understanding, critical thinking, and active knowledge creation. It encourages students to engage in advanced cognitive processes and effective communication. The intellectual dimension values understanding essential concepts and skills rather than mere memorization. Students are encouraged to express their thoughts, participate in discussions, and collaborate with peers to enhance comprehension. AI supports cognitive development with personalized learning, adaptive content, immediate feedback, and intelligent tutoring. It fosters higher-order thinking, creativity, and self-reflection by reducing routine tasks and providing data-driven insights.

Physical dimension

The physical aspect of a learning environment encompasses structural elements such as technology, equipment, and furniture (Hannafin and Land 1997). The classroom's physical setup and available resources can either support or hinder various teaching strategies (Beckers 2019; Marmot 2014). Research indicates that color, texture, vistas, light, acoustics, temperature, and air quality are crucial components of the physical learning environment (Marmot 2014), although aesthetic factors are seen as less significant (Beckers 2019). AI transforms physical learning spaces into tech-enabled environments with smart classrooms, digital devices, VR/AR, and remote learning tools. It also raises ergonomic concerns, particularly with increased screen time.

Affective dimension

The emotional dimension includes students' attitudes and perceptions. Their beliefs and feelings about learning and their abilities greatly affect the learning process. Motivation, which refers to the drive and excitement to engage in education, is another key component. A student's self-efficacy, or their confidence in being successful in educational tasks, also plays a role. Without self-belief, students may struggle in their learning efforts. Additionally, learning styles and preferences matter; every learner is unique and requires tailored instruction to meet their needs. The best ways individuals learn e.g visual, auditory, or kinesthetic are crucial considerations for the learning environment. AI influences emotions and motivation through personalized feedback, emotional recognition tools, and supportive systems. However, an over-reliance on AI may diminish emotional connections and lead to feelings of isolation.

Pedagogical dimension

The pedagogical aspect of the learning environment (Skordi and Fraser 2019) pertains to the activities, tools, resources, methods, tactics, and frameworks employed by the instructor to facilitate student learning (Hannafin and Land 1997). A quality learning space provides students with an optimal environment for social relations, collaborative work and participation, thus fostering innovation and incorporating active methodologies (Poyato *et al*, 2024). AI reshapes teaching methods by automating assessments, supporting individualized instruction, generating learning materials, and shifting the teacher's role from content deliverer to facilitator and data interpreter.

Psychosocial dimension

This dimension addresses the origins of human behaviour. Personalization, involvement, student cohesion, contentment, task orientation, innovation, individualization, investigation, cooperation, equity, and teacher support are some of the aspects that define psychosocial settings. AI influences social dynamics via facilitating collaborative tools, functioning as a social actor, fostering inclusivity, and combating bullying. However, if access is unequal, it may limit human-to-human interaction while widening digital differences.

AI's impact on the learning environment is complex and significant. It fosters intellectual growth through personalization, expands physical and virtual learning settings, alters emotional experiences, transforms pedagogical approaches, and reimagines social interactions in educational communities. However, these benefits come with risks, which must be carefully handled to ensure that AI enriches rather than disrupts the entire learning environment. AI and other technology radically altered the educational landscape, gradually displacing traditional learning and teaching frameworks.

Learning and Artificial intelligence

Artificial intelligence refers to the capacity of a computer or computer-operated robot to execute tasks typically linked to human cognitive processes, including reasoning. While no AIs now exhibit complete human flexibility across diverse domains or in activities necessitating extensive everyday knowledge, certain AIs execute certain tasks comparably to humans.

AI personalizes learning experiences for students, tailoring to their specific needs and abilities while offering real-time feedback on their progress. In contrast, virtual and augmented reality (VR/AR) facilitate immersive

learning experiences, enabling students to explore and engage with virtual environments and simulations. (Alam, 2023).

AI-driven adaptive learning systems have revolutionized education by providing personalized learning experiences customized to specific student requirements, hence improving engagement and outcomes. A study by Sari et al. (2024) emphasized the capacity of AI-driven systems to improve educational quality and equity. It delineates challenges, such as institutional technical preparedness, educator training, and infrastructural requirements, which are essential for effective implementation.

AI affects learning through enhancing educational resources in the following ways:

- Providing customized Feedback: AI-driven insights empower educators to provide prompt, individualized responses, facilitating student learning from errors while enabling teachers to concentrate on more profound coaching.

- Augmenting Engagement: AI-driven tools facilitate educators in developing more dynamic and immersive educational experiences while maintaining the fundamental student-teacher relationship.

- Optimizing Administrative Functions: Through the automation of grading and standard tests, AI enables educators to allocate increased time to student interaction, mentorship, and the enhancement of teaching methodologies (Ghamrawi et al., 2024).

- Deliver Customized Feedback: Prompt, individualized comments facilitate students' comprehension of their errors.

- Augment Engagement: Interactive AI tutors and chatbots can replicate individualized tutoring experiences.

- Optimize Administrative Duties: Automating grading and assessments allows instructors to allocate more time to instruction.

Learning environment and Artificial Intelligence

Students' evaluations of their learning environment are a more significant predictor of learning outcomes than previous academic achievement (Lizzio et al., 2002). A study in Pakistan indicated that the learning environment consists of teaching for comprehension, evaluation, teacher-student contact, curricular consistency, active learning, and peer relationships. The study indicated the necessity of designing teacher training programs to enhance pedagogical methods and evaluation methodologies. This will foster an active learning environment that is conducive to achieving optimal learning outcomes for students (Raza, 2019). Vermeulen and Schmidt (2008 found that a conducive learning environment enhances student motivation, thereby improving learning. They contend that the learning environment is crucial for students' learning outcome.

AI can transform educational settings by personalizing training, providing timely feedback, and meeting a wide range of learning needs. This promotes a more engaged and inclusive learning experience. Technologies are radically changing human cognitive processes, instructional approaches, and activities in unforeseen ways (Collins & Halverson, 2010). Conventional Information and Communication Technology (ICT) tools that enhance learning environments, including projectors, digital whiteboards, and digital textbooks, are augmented by an array of interactive educational technologies, such as games, robots, virtual reality (VR), computer simulations, block-based programming, and the Internet of Things (Weng & Chiu, 2023).

Generative AI (GenAI) is a permanent fixture, representing only the inception of advancements in new technology. The inquiry has shifted from "Should we grant students access to AI?" to "How should students engage with AI?" (NCEE, 2024). Student experiences must be organized to ensure that learning is real, pertinent, and significant, utilizing the latest sophisticated technology (*Framework for AI-Powered Learning Environments. Pdf*, n.d.). Research by Jafari (2024) indicated that AI exhibited considerable potential in

comprehending emotions and sentiments within an educational context while Elimadi et al. (2024) found that AI has the capacity to enhance student learning outcomes via personalized and adaptable learning experiences.

Learning outcomes and Artificial Intelligence

Learning outcomes delineate the particular knowledge, abilities, or competencies that a learner will acquire from an educational activity. A learning outcome is a capability that students have acquired that they did not possess before. It constitutes a transformation in individuals stemming from an educational experience (Maher, 2004). Learning activities occur inside the learning environment. Learning outcomes are integral to assessment and evaluation, articulating the knowledge that learners are expected to acquire upon the completion of the educational activity. An effectively articulated learning outcome would emphasize the learner's capacity to apply acquired knowledge in practical scenarios, rather than merely reciting facts.

AI influences learning outcomes since learners' interactions in an AI enhanced environment affect their learning and consequently, the learning outcome. Learning outcomes are progressively being shaped by AI tools which are increasingly accommodating learners' diverse needs. A study by Vieriu and Petrea (2025) in Bucharest demonstrated that AI provides substantial advantages, such as personalized learning, greater academic performance, and increased student engagement. This indicates that of AI has advanced to influence learning outcomes. Utilizing AI as an auxiliary resource, educators can improve educational outcomes while preserving their essential function in fostering student development (*AI Impact on Education*, n.d.) (Kim et al., 2022).

AI chatbots significantly influence students' learning outcomes (Wu & Yu, 2024). They exert a more significant impact on learners in higher education than on those in basic and secondary education. Moreover, brief interventions demonstrated a more significant impact on students' learning outcomes compared to extended interventions. The novelty effects of AI chatbots may enhance learning results during brief interventions, but these advantages diminish with prolonged engagements. Employing chatbots can greatly enhance student learning experiences by allowing them to study at their own speed with less stress, saving them time, and keeping them motivated (Ait Baha et al, 2024). Future designers and educators ought to enhance students' learning results by integrating AI chatbots with anthropomorphic avatars, gamification features, and emotional intelligence.

The integration of information technology with education and pedagogy is intensifying in the realm of educational informatization. Advanced information technologies, particularly AI, have effectively enhanced the teaching process and elevated educational quality (Xie, 2023). Education has been transformed by AI through the customization of learners' experiences to meet their individual needs. This augmentation of learning through engagement leads to positive learning outcomes (Pratama et al., 2023). Personalised learning, a paramount benefit of AI in education, facilitates improved student outcomes by allowing learners to progress at their own pace and in alignment with their preferred learning styles. Intelligent tutoring systems, chatbots, and automated grading and assessment enhance efficiency, conserve educators' time, and deliver more precise and consistent feedback.

The relationship between AI and learning outcomes is complex and multidimensional, encompassing not only academic performance but also motivational, engagement, and equity-related outcomes. One of the strongest relationships between AI and learning outcomes stems from AI's ability to deliver personalized and adaptive learning. Traditional classrooms often apply a "one-size-fits-all" approach. Here, the same pace, content, and feedback is applied across board which may not suit all learners. AI can help bridge that gap by individualising instruction to suit each learner's needs. AI-driven systems such as intelligent tutoring systems (ITS), adaptive learning platforms, and learning analytics systems tailor content, pace, and feedback based on a student's strengths, weaknesses, and progress (Merino-Campos, 2025). This personalization often results in higher academic performance, improved knowledge retention, and increased satisfaction. Baillifard, (2023) conducted a case study of a "personal AI tutor" used with university students. The study revealed that those who actively engaged with the AI tutor achieved significantly higher exam grades compared to those who did not. Thus, by offering individually tailored learning experiences AI helps optimize learning for many students.

Beyond academic performance, AI's influence extends to motivation, engagement, confidence, and self-efficacy; all of which indirectly support better learning outcomes. A study by Xu (2025) found that AI-driven

personalized feedback significantly predicted students' goal achievement, self-efficacy, and learning engagement. Through timely, adaptive feedback, AI helps learners feel more in control and confident in their learning journey. A study by Keong (2025) reported increased motivation when AI driven facilities are used. Additionally, Li (2025) found that AI enabled STEM education increased learning outcomes among learners. Therefore, AI helps not just by giving content, but by shaping the learner's experiences which in turn supports sustained learning.

AI affects the structural and operational aspects of education, freeing up resources and providing prompt data-driven support, resulting in better learning results. AI minimizes teacher workload by automating administrative chores such as grading and routine evaluations (Tapalova, 2022). Furthermore, AI-powered learning analytics can detect at-risk pupils early. This enables targeted interventions before risks become established, resulting in undesirable consequences like as dropouts or poor academic performance (Merino-Campos, 2025). Because of these structural benefits, AI can scale excellent teaching and support to many more learners, maximizing resource utilization while promoting superior learning outcomes.

Inequalities exist in learning outcomes for learners left behind in the traditional classrooms. In such scenarios, AI provides adaptive and individualized approaches to solve such challenges. A study by Hao (2025) of an AI learning environment found that students who used co-constructive interactions with AI showed higher learning gains and motivation than their peers (Hao, 2025). Another study revealed that AI can support differentiated instruction thereby helping learners with diverse backgrounds, learning styles, or initial competencies (Hariyanto et al, 2025). Additionally, teachers and students perceive AI as helpful in identifying individual needs and customizing learning (A Alomair, 2024). This helps narrow achievement gaps between stronger and weaker students. Thus, when thoughtfully implemented, AI has potential to offer tailored support for learners who might otherwise struggle in standardized systems.

While the relationship between AI and positive learning outcomes is strong and promising, it is not automatic or guaranteed. Several challenges can moderate or undermine this relationship. Challenges related to limited access and infrastructure lead to low adoption of AI tools (Matere, 2024). Teachers also need training to enable AI integration into the curriculum. Without proper teacher training, AI tools risk being under-utilized or misused.

Merino-Campos (2025) observed that ethical and privacy concerns, algorithmic bias, and data security can be a challenge to using AI in education. He adds that the use of student data for AI-driven personalization raises legitimate privacy and fairness concerns. To realize the benefits of AI in education, stakeholders must address infrastructural, professional, ethical, and research-quality challenges. Through personalization, adaptive feedback, efficient administration, and enhanced engagement, AI can significantly improve academic performance, motivation, equity, and learning efficiency. However, realizing these benefits depends heavily on access, infrastructure, teacher capacity, ethical implementation, and rigorous pedagogical integration. As AI becomes more embedded in educational systems worldwide, stakeholders must approach adoption thoughtfully, balancing enthusiasm with responsibility.

The synergistic relationship

AI transforms the learning environment by introducing personalization, adaptivity, and responsive feedback loops. For example, adaptive learning systems adjust content difficulty based on real-time performance data, creating an environment tailored to individual needs (Holmes et al., 2019). Such environments foster engagement and reduce cognitive overload, thereby supporting better learning outcomes.

The effectiveness of AI tools depends heavily on the environment in which they are used. Supportive environments which are characterized by teacher readiness, adequate infrastructure, and positive learner attitudes, maximizes AI's impact (Luckin et al., 2016). However, if the environment is poorly equipped or lacks teacher competence, AI may not improve outcomes despite its potential.

When AI operates within an enabling learning environment, learning outcomes improve significantly. Research shows that students in AI-enhanced environments demonstrate: higher academic achievement, deeper conceptual understanding, improved self-regulation and increased motivation and engagement (Koedinger et al., 2015;

Holmes et al., 2019). This improvement occurs because AI supports personalized progression, while the learning environment supports emotional safety and sustained engagement.

The synergy among the three variables forms a circular process: AI reshapes and improves the learning environment; a strong learning environment increases the effectiveness of AI: enhanced learning outcomes justify further integration and refinement of AI tools; and improved AI tools further refine the learning environment. Thus, the relationship is not linear but self-reinforcing, where each component strengthens the others.

The use of Intelligent Tutoring Systems in Collaborative Classrooms has permeated current learning environments. In such set ups, intelligent tutoring systems provide individualized feedback while teachers facilitate group discussions. The supportive environment encourages collaboration, while AI ensures personalized learning, leading to increased achievement and motivation (Woolf et al., 2013). Another example is use of AI-Supported learning analytics in higher education. In such scenarios, learning analytics platforms identify students at risk and support timely interventions. In environments where instructors actively use this data, learning outcomes which include retention and pass rates, improve significantly (Holmes et al., 2019). Additionally, AI can be used in inclusive learning environments by providing speech-to-text, predictive text, or adaptive reading support. Such create inclusive environments for students with disabilities. In such environments, learners demonstrate improved confidence and academic performance (Luckin et al., 2016).

These examples show that AI alone is not responsible for improved outcomes. Rather it is the interaction between AI and the learning environment that produces the strongest effects. Recognizing this synergistic relationship improves decision-making around AI adoption in education. A synergistic interaction transpires when two entities provide a more significant impact collectively than they would separately. Synergistic interactions are founded on the co-creation of outcomes. The learning environment, learning outcomes, and AI possess a distinctive interrelationship. Bandura's social cognitive theory posits that an individual's behaviour, personal attributes, and the surrounding environment are in a continuous state of interaction. A modification in one element influences the results of the others (Van der Bijl, J. J., & Shortridge-Baggett, L. M., 2002). This study demonstrates that AI has significantly transformed the learning environment in undeniable ways. Consequently, the learning outcomes or the conduct of learners is destined to change.

The figure shows the synergistic relationship between learning environment, learning outcomes and artificial intelligence.
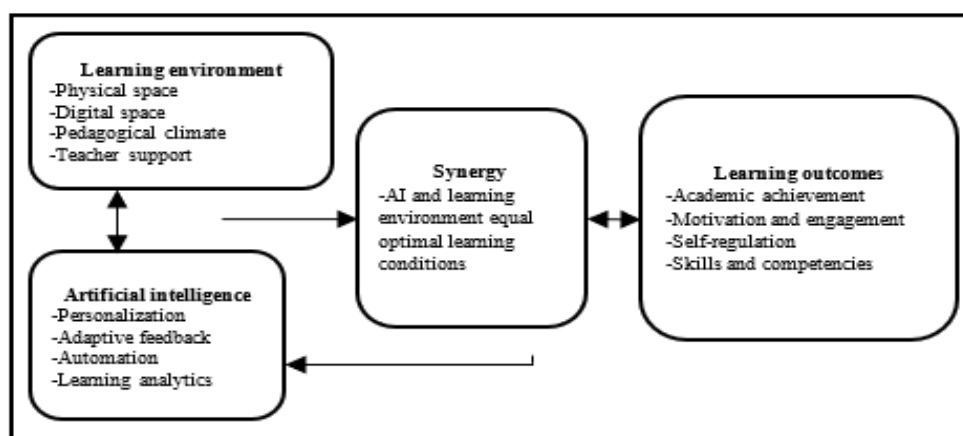
The synergistic relationship between AI, learning environment and learning outcome

AI enhances the learning environment making it more adaptive, responsive, personalized and efficient. Additionally, having a supportive learning environment amplifies the effectiveness of AI by ensuring usability, acceptance and meaning teacher-student interaction. Improved learning outcomes reinforce the adoption and refinement of AI tools and leaning environments forming a continuous cycle. Moreover, the synergy between AI and the learning environment leads to optimal learning experiences which in turn improves learning outcomes.

CONCLUSION

The incorporation of Artificial Intelligence (AI) in education significantly alters learning experiences by converting conventional classrooms into dynamic and individualized learning environments. AI technologies provide personalized assistance, instantaneous feedback, and customized learning pathways, resulting in improved student engagement, motivation, and academic achievement. The relationship between AI, the learning environment, and learning outcomes is deeply interconnected. AI enriches the learning environment through personalization and analytics, while supportive learning environments enhance the effectiveness of AI. Together, they create a synergy that leads to improved engagement, motivation, and academic performance. Understanding this three-way relationship is crucial for educators, researchers, and policymakers aiming to harness AI's full potential in transforming education.

RECOMMENDATIONS

In a rapidly evolving educational landscape driven by technological advancements, it is imperative for educators to alter their perspectives on teaching and learning. The introduction of AI, AR, and VR in the education industry has fundamentally transformed learning environments and, consequently, learning outcomes. It is thus advisable for educators to adopt the novel modifications to enhance the educational experience for the digital natives that comprise the present generation of learners.

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