

SYSTEMATIC REVIEW

AI-Powered Adaptive Learning Systems in Higher Education: A Scoping Review of Implementation and Impact on Academic Performance

Sistemas de Aprendizaje Adaptativo con Inteligencia Artificial en la Educación Superior: Revisión Exploratoria sobre Implementación e Impacto en el Rendimiento Académico

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ABSTRACT

Artificial intelligence (AI)-powered adaptive learning systems are revolutionizing higher education by delivering real-time, personalized learning experiences that align with individual student progress. This scoping review maps current evidence on the implementation of such systems in e-learning platforms and evaluates their educational impacts. Fourteen empirical studies published between 2013 and 2025 were systematically analyzed following Arksey & O'Malley and Joanna Briggs Institute methodologies. Findings reveal consistent improvements in academic performance, engagement, retention, and satisfaction across diverse disciplines including law, engineering, dentistry, and language education. Key features enhancing these outcomes include adaptive feedback, curriculum-aligned personalization, and real-time analytics. Nonetheless, barriers such as faculty resistance, ethical concerns like data privacy and algorithmic bias, and regional disparities in adoption—especially in Latin America and Sub-Saharan Africa—persist. The review underscores the transformative potential of AI-based adaptive learning systems while highlighting the need for inclusive design, long-term evaluation, and equitable implementation strategies in higher education.

Keywords: Adaptive Learning Systems; Artificial Intelligence in Education; Personalized Learning; Academic Performance; Higher Education Technology; Student Engagement; Learning Analytics.

RESUMEN

Los sistemas de aprendizaje adaptativo impulsados por inteligencia artificial (IA) están transformando la educación superior mediante experiencias de aprendizaje personalizadas y en tiempo real que se ajustan al progreso individual del estudiante. Esta revisión exploratoria mapea la evidencia actual sobre la implementación de dichos sistemas en plataformas de aprendizaje en línea y evalúa su impacto educativo. Se analizaron sistemáticamente catorce estudios empíricos publicados entre 2013 y 2025, siguiendo las metodologías de Arksey & O'Malley y del Instituto Joanna Briggs. Los hallazgos evidencian mejoras consistentes en rendimiento académico, compromiso, retención y satisfacción en disciplinas como derecho, ingeniería, odontología y enseñanza de idiomas. Las características clave que potencian estos resultados incluyen retroalimentación adaptativa, personalización alineada al currículo y analítica en tiempo real. No obstante, persisten barreras como la resistencia docente, preocupaciones éticas relacionadas con la privacidad de datos y el sesgo algorítmico, así como desigualdades regionales en la adopción—especialmente en América Latina y África Subsahariana. Esta revisión resalta el potencial transformador de los sistemas adaptativos con IA y la necesidad de un diseño inclusivo, evaluación a largo plazo y estrategias de implementación equitativas en la educación superior.

Palabras clave: Sistemas de Aprendizaje Adaptativo; Inteligencia Artificial en la Educación; Personalización del Aprendizaje; Rendimiento Académico; Tecnología Educativa Superior; Compromiso Estudiantil; Analítica del Aprendizaje.

INTRODUCTION

The implementation of online learning platforms that incorporate adaptive artificial intelligence is transforming higher education by personalizing learning experiences according to each student's individual progress. These platforms employ data-driven approaches to adjust both content and learning pace, thereby increasing student engagement and enhancing academic outcomes.

AI-powered systems analyze student data, including performance metrics and learning styles, to design personalized learning paths.⁽¹⁾ Research indicates that personalized learning can improve student performance by up to 30 % and increase engagement by over 60 %.⁽²⁾ Furthermore, these platforms provide real-time feedback and assessment, which has been shown to reduce faculty workload by nearly 40 %, allowing for more meaningful student-teacher interactions. Immediate feedback can also improve retention rates by approximately 50 %, ensuring that students receive timely support when needed.⁽²⁾

However, the integration of artificial intelligence also presents significant challenges, including algorithmic bias, privacy concerns, and the need to ensure equitable access to technology. To prevent unintended inequalities in educational outcomes, it is essential that AI systems are developed by diverse teams and framed within inclusive design principles.⁽³⁾

Despite the growing enthusiasm surrounding the integration of adaptive artificial intelligence in higher education, the implementation of these systems across e-learning platforms remains uneven and insufficiently understood. While several studies highlight promising outcomes such as increased engagement, improved retention, and personalized learning pathways there is a lack of comprehensive insight into how these technologies are actually being deployed in real-world educational settings and what specific impacts they are producing. The variability in technological infrastructure, institutional readiness, and pedagogical frameworks across universities further complicates the picture, leading to significant disparities in the adoption and effectiveness of these AI-driven systems.

Moreover, the rapid advancement of adaptive AI tools has outpaced the development of standardized guidelines and evaluative frameworks, making it difficult to assess their true educational value and scalability. In particular, questions persist about how these platforms influence student learning experiences in diverse academic contexts, how instructors adapt to their use, and what long-term effects they may have on teaching practices and academic performance. The ethical concerns surrounding algorithmic transparency, data privacy, and equitable access only deepen the complexity of the issue.

Given this scenario, it becomes essential to explore in greater depth how adaptive AI-based learning systems are being implemented and what measurable impacts they have on learning in higher education. This study addresses that need by examining the deployment of e-learning platforms that automatically adjust content and learning pace based on student progress, with the aim of identifying current practices, challenges, and opportunities, and contributing to a more nuanced understanding of their role in contemporary educational contexts.

METHOD

Study Design

A scoping review design was adopted, based on the methodological framework proposed by Arksey et al.⁽⁴⁾ refined by Levac et al.⁽⁵⁾ and aligned with the Joanna Briggs Institute guidelines.⁽⁶⁾ This design was considered appropriate to map key concepts, identify the types of available evidence, and explore research gaps related to the implementation of adaptive learning systems using AI in e-learning environments.

Inclusion Criteria

Original research articles using quantitative, qualitative, or mixed-methods designs were included. Eligible studies had to report on the implementation of AI-driven adaptive learning systems within e-learning platforms and provide outcomes related to learning such as cognitive performance, motivation, attitudes, academic achievement. Only studies conducted in the context of higher education were considered. Publications dated between 2013 to present were included, with no restrictions on language.

Exclusion Criteria

Studies were excluded if they were conducted in primary, secondary, or continuing education contexts. Additional exclusions included review articles (systematic, metanalysis or narrative), editorials, commentaries,

letters to the editor, book chapters, and conference abstracts. Articles without access to full text were also excluded.

Search Strategy

The search was conducted in three electronic databases: PubMed, Scopus, and Web of Science (WoS).

The principal terms were selected according to the PICO and the formulations were structured as shown in table 1.

Table 1. Structured Summary: terms by PICO Component		
Component	Keywords	MeSH Terms
Population (P)	students, learners, online learners, e-learning users.	Students, Education, Distance.
Intervention (I)	adaptive learning systems, AI in education, intelligent tutoring systems, learning analytics.	Artificial Intelligence, Machine Learning, Educational Technology, Computer-Assisted Instruction.
Comparator (C)	traditional e-learning, non-adaptive systems.	Education, Computer-Assisted Instruction.
Outcome (O)	academic performance, learning outcomes, motivation, knowledge retention.	Learning, Motivation, Achievement, Educational Measurement, Retention.

A structured search strategy was developed combining terms related to three key thematic areas. Boolean operators (AND/OR) and adapted to the syntax of each database to maximize search sensitivity.

Table 2. Queries and filters applied by database in the search		
Database	Formulation	Filters
Pubmed	(("Students"[MeSH Terms] OR "Education, Distance"[MeSH Terms] OR students[Title/Abstract] OR learners[Title/Abstract] OR "online learners"[Title/Abstract] OR "e-learning users"[Title/Abstract]) AND ("Artificial Intelligence"[MeSH Terms] OR "Machine Learning"[MeSH Terms] OR "Computer-Assisted Instruction"[MeSH Terms] OR "Educational Technology"[MeSH Terms] OR "adaptive learning"[Title/Abstract] OR "adaptive learning systems"[Title/Abstract] OR "AI in education"[Title/Abstract] OR "intelligent tutoring systems"[Title/Abstract] OR "personalized learning"[Title/Abstract] OR "machine learning in education"[Title/Abstract] OR "learning analytics"[Title/Abstract]) AND ("Learning"[MeSH Terms] OR "Achievement"[MeSH Terms] OR "Motivation"[MeSH Terms] OR "Educational Measurement"[MeSH Terms] OR "Retention (Psychology)"[MeSH Terms] OR "academic performance"[Title/Abstract] OR "learning outcomes"[Title/Abstract] OR "student engagement"[Title/Abstract] OR "learning motivation"[Title/Abstract] OR "knowledge retention"[Title/Abstract]) AND ("traditional learning"[Title/Abstract] OR "conventional e-learning"[Title/Abstract] OR "non-adaptive platforms"[Title/Abstract] OR "standard online learning"[Title/Abstract]))	Filters applied: Clinical Study, Clinical Trial, Controlled Clinical Trial, Randomized Controlled Trial.
Scopus	((students OR learners OR "online learners" OR "e-learning users") AND ("adaptive learning" OR "adaptive learning systems" OR "AI in education" OR "intelligent tutoring systems" OR "personalized learning" OR "machine learning in education" OR "learning analytics" OR "AI-powered learning" OR "adaptive e-learning") AND ("academic performance" OR "learning outcomes" OR "student engagement" OR "learning motivation" OR "knowledge retention" OR "learning efficiency" OR "skill acquisition") AND ("traditional learning" OR "conventional e-learning" OR "non-adaptive platforms" OR "static online learning"))	AND (LIMIT-TO (DOCTYPE , "ar"))
WoS	TS=((students OR learners OR "online learners" OR "e-learning users") AND ("adaptive learning" OR "adaptive learning systems" OR "AI in education" OR "intelligent tutoring systems" OR "personalized learning" OR "machine learning in education" OR "learning analytics" OR "AI-powered learning" OR "adaptive e-learning") AND ("academic performance" OR "learning outcomes" OR "student engagement" OR "learning motivation" OR "knowledge retention" OR "learning efficiency" OR "skill acquisition") AND ("traditional learning" OR "conventional e-learning" OR "non-adaptive systems" OR "static online learning"))	Refined By: Document Types: Article

Study Selection Process

Following the database search, all references were exported to a reference management software Rayyan® for deduplication. Subsequently, titles and abstracts were screened independently by two reviewers to identify potentially eligible studies based on the predefined inclusion and exclusion criteria. Any disagreement was resolved through discussion and consensus. If necessary, a third reviewer was consulted to resolve persistent discrepancies. Full-text screening was then conducted to confirm the eligibility of the selected studies. During this stage, it was verified that each article explicitly addressed the implementation of adaptive learning systems using AI in e-learning platforms and reported measurable outcomes related to learning. Reasons for exclusion were systematically recorded. The entire selection process was documented using a PRISMA-ScR flow diagram, which summarized the number of records identified, screened, excluded, and included in the final review.

Data Extraction and Analysis

Data extraction was conducted using a structured matrix that included the following variables: author(s), year and country of publication, type of e-learning platform, type of AI technology used, educational level of the target population, adaptive parameters addressed (e.g., content, pace, feedback), research methodology employed and reported learning outcomes. A descriptive and thematic synthesis was carried out to identify patterns in implementation strategies, types of adaptive technologies, and reported impacts. The results were presented through narrative summaries and tables to enhance interpretability.

Ethical Considerations

As this review was based exclusively on previously published literature, ethical approval was not required.

RESULTS

Initially, a total of 441 records were identified from three databases: PubMed (n = 12), Scopus (n = 412), and Web of Science (n = 17). Before screening, 16 duplicate records were removed, resulting in 425 records eligible for the initial screening phase based on titles and abstracts.

In the screening phase, a substantial number of studies were excluded for various reasons. Specifically, 21 records were excluded for not being original research, 283 for irrelevant study designs, and 92 for not meeting the predefined inclusion criteria. This screening resulted in 29 reports sought for retrieval, all of which were successfully retrieved.

These 29 reports underwent a comprehensive full-text assessment for eligibility, leading to the exclusion of an additional 15 records. Among these, 6 were excluded as they were not directly related to the research topic, 4 due to incomplete data, and 5 because full texts were unavailable. The detailed eligibility assessment yielded 14 studies that were included in the systematic review for further qualitative and quantitative synthesis (figure 1).

The analyzed studies presented significant global and specific outcomes related to the implementation of adaptive learning platforms in higher education contexts. Across the included articles, adaptive learning systems demonstrated considerable positive effects on students' academic performance, engagement, and motivation.

Research from Alwadei et al.⁽⁷⁾ dentistry students utilizing an Adaptive Learning Platform (ALP) demonstrated significant learning gains, improved retention of knowledge, and enhanced self-efficacy. These students showed statistically significant higher post-test scores compared to traditional learning environments.

The study of Hakim et al.⁽⁸⁾ describes engineering students interacting with the curriculum-trained AI chatbot Genie-on-Demand experienced notable improvements in learning outcomes, motivation, and satisfaction, reflecting the efficacy of AI-driven personalized interactions.

In Choi et al.⁽⁹⁾ undergraduate students engaged in sustainability education using the Classlet metaverse platform reported heightened enjoyment, ease of use, and positive perceptions regarding the quality of learning experiences. The intervention fostered high intent to reuse the platform.

In Arsovic et al.⁽¹⁰⁾ the Moodle-based adaptive e-learning system implemented among education students significantly improved retention, task completion, test results, and engagement, further supporting the adaptability benefits inherent in personalized educational technologies.

In the research of Chen et al.⁽¹¹⁾ English majors involved in a blended course incorporating adaptive writing tasks and personalized feedback showed statistically significant improvement in their writing performance, overall engagement, and course satisfaction.

From a theoretical perspective, the qualitative grouping of findings underscores several key concepts. Real-time feedback, personalized learning paths, adaptive tasks, tailored feedback mechanisms, and curriculum-specific personalized responses emerged as critical features enhancing learner performance and engagement. Additionally, aligning adaptive interventions with specific curriculum goals and targeted competencies reinforced the theoretical notion that effective personalization closely corresponds with educational objectives and learner needs.

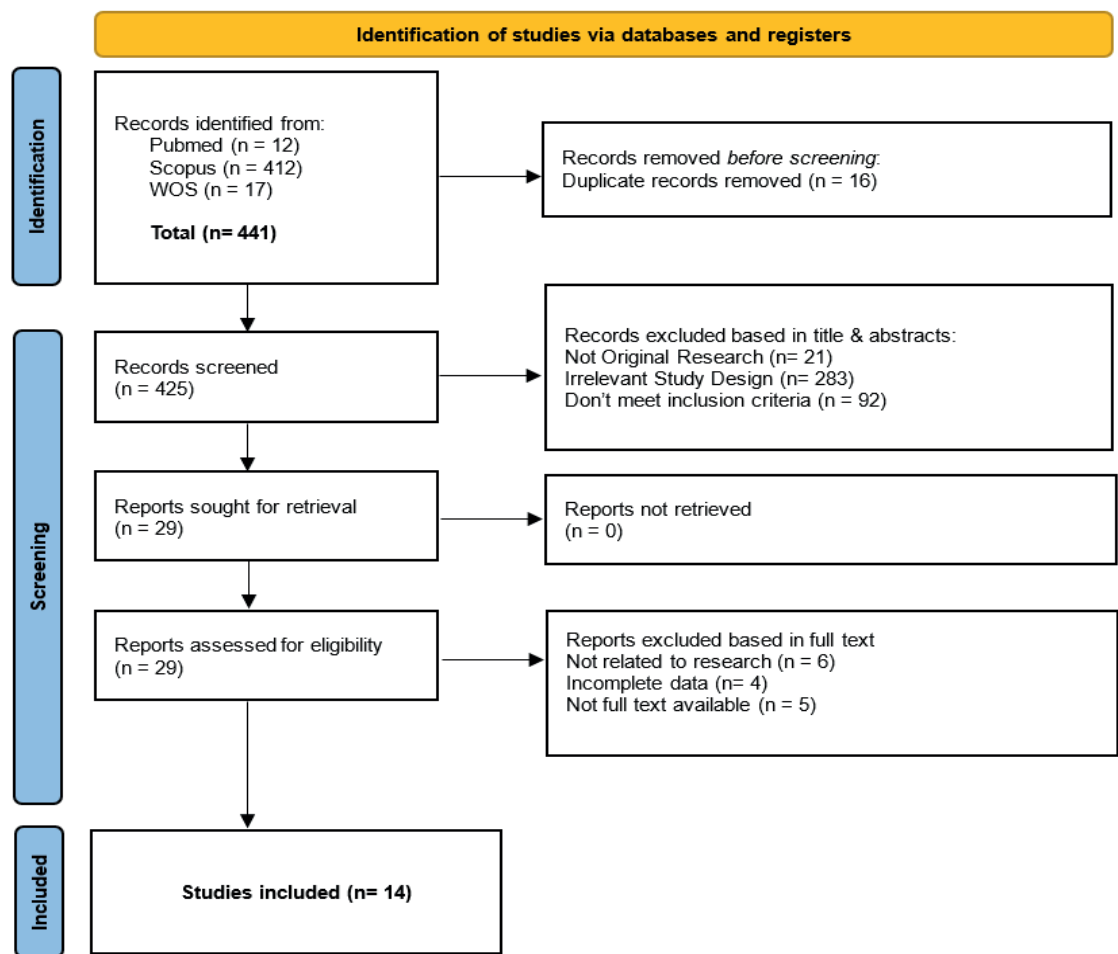


Figure 1. PRISMA Flowchart

Collectively, these results affirmed the positive impact and theoretical advantages of employing adaptive learning platforms in various academic fields, demonstrating their broad applicability and effectiveness in higher education contexts (table 2).

Geographically, the body of research on adaptive learning systems in higher education reveals a concentration of scholarly activity in regions marked by rapid digital transformation and increasing investment in educational innovation. The distribution of studies suggests a notable engagement from Asian countries, particularly East and Southeast Asia, where technological integration in education has become a strategic national priority. This regional focus may reflect a broader cultural and policy-level emphasis on technological advancement, digital literacy, and competitive academic performance.

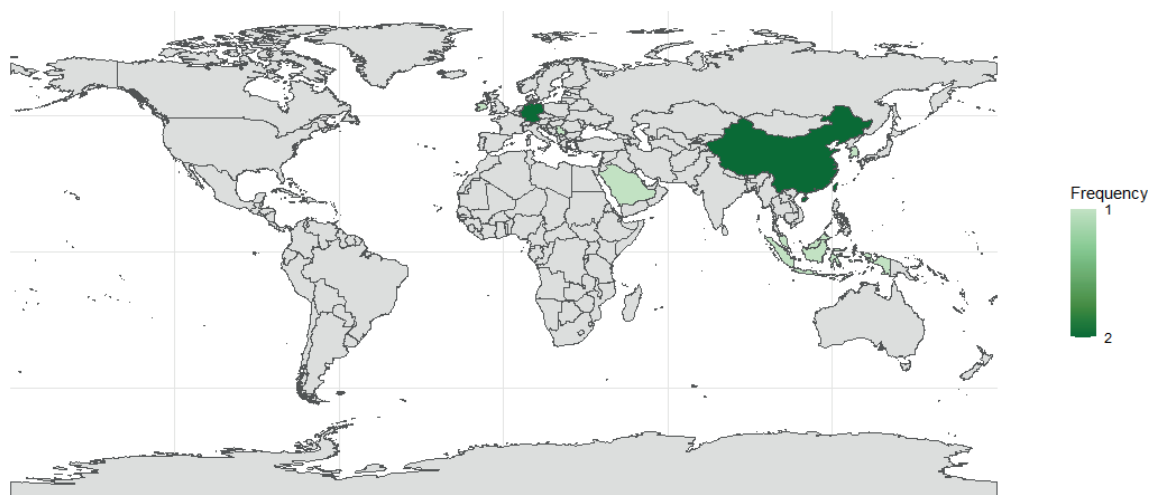


Figure 2. Frequency of Countries in Adaptive Learning Research

Table 3. Summary of adaptive learning interventions and their impact on student performance and engagement in higher education by participant profile, degree field, adaptive systems used, methods, and key outcomes

Author	N	Participants	Adaptive System Used	Intervention Method	Personalization/ Adaptation	Impact on Performance/ Engagement	Key Outcomes
Alwadei ⁽⁷⁾	343	Dentistry students	Adaptive Learning Platform (ALP)	Comparison between face-to-face and ALP-enhanced blended learning in a 4-week preparatory course for NBDE	Tailored learning paths based on pre-test, progress monitoring, and real-time adaptive content delivery using Bayesian estimation	Higher post-test scores in summative ALP group compared to formative and traditional; increased motivation and content mastery	Significant learning gains and better performance in final exams with adaptive system; highest effectiveness in summative ALP group
Arsovic et al. ⁽¹⁰⁾	162	Education and pre-school teacher students	Moodle-based adaptive e-learning system	Students split into groups using adaptive vs. traditional LMS. Personalized content delivery based on FLSM learning styles and prior knowledge	Adaptation based on pre-identified learning styles and pre-tests, with ongoing personalization based on user interactions	Improved retention, task completion, test results, and engagement for students in the adaptive group	Statistically significant higher performance in adaptive LMS group; faster task completion and higher engagement levels
Chen ⁽¹¹⁾	33	English majors	MOOC with formative assessments and Zuvio platform	Blended course with weekly quizzes, discussion boards, teacher feedback, self and peer assessment, and paragraph writing tasks	Adaptive writing tasks and personalized feedback using multiple formative assessment activities	Improved writing performance, engagement, and metacognitive reflection through formative assessment	Statistically significant improvement in post-test writing performance; students valued teacher feedback and interactive learning
Choi ⁽⁹⁾	54	Undergraduate students	Classlet metaverse platform	Students completed scenario-based sustainability challenges using the metaverse (VR, desktop, mobile); pre/post survey and tasks	Real-time interaction tracking, avatar-based learning, self-paced task design, customizable interaction levels	Enjoyment, ease of use, and perceived learning gains predicted higher intention to use platform; immersion increased engagement	High intent to reuse metaverse platform; enhanced understanding and retention; strong predictors included ease of use and enjoyment
Hakim ⁽⁸⁾	106	Engineering students	Genie-on-Demand (custom AI chatbot)	Students interacted with a curriculum-trained chatbot to learn OHS topics; compared with traditional and conventional chatbot (ChatGPT) approaches	Responses tailored to specific curriculum materials uploaded by educators; contextualized answers based on learning path	Higher posttest scores, increased self-efficacy, and greater technology acceptance than other groups	Custom chatbot improved learning, motivation, and perceived usefulness significantly over ChatGPT and traditional methods
Ipinnaiye et al. ⁽¹²⁾	600	Economics students	LearnSmart (McGraw-Hill Connect)	Weekly adaptive assignments with personalized paths based on pre-test questions; not graded but required for weighted assessment inclusion	System adjusted questions based on student confidence and responses to reinforce weak areas	Completion of more assignments was positively associated with test performance	Adaptive assignments increased performance, while time alone was not a reliable success indicator; quality of engagement was key
Liu ⁽¹³⁾	66	Foreign language students	French Assistant (AI-based app)	Experimental group used ACF-PA (Automated Corrective Feedback-Peer Assessment) with French Assistant app for pronunciation, compared to Conventional Peer Assessment	Real-time personalized feedback using automatic speech recognition (ASR); peer assessment integrated with adaptive AI feedback	Improved learning achievement, intrinsic motivation, and self-regulated learning compared to control group	Significantly better posttest scores, motivation, and self-regulated learning in ACF-PA group

Setyosari ⁽¹⁴⁾	100	Informatics engineering students	Adaptive Educational Hypermedia System (AEHS)	Students were grouped by VARK learning styles and received content adapted to their preferred modality via AEHS platform	Learning materials personalized according to VARK profile (visual, auditory, read/write, kinesthetic)	Higher average post-test scores in AEHS group than in web-based group; gain score 0,735 (high)	Significant improvement in learning outcomes using AEHS compared to web-based learning
Tsekhmister ⁽¹⁵⁾	167	Medical students	Behavioral analytics-informed personalized learning system	Case study across 3 institutions using Kolb's learning styles to personalize digital education	Learning environment adapted based on behavioral analytics and learning styles (converger/accommodator) with suitable teaching strategies	Average efficiency index increased by 3,9 % across institutions	Personalized learning improved performance and engagement; enhanced quality of digital medical education
Wambsganss ⁽¹⁶⁾	83	University students	ArgumentFeedback (ML/NLP-based writing tool)	Students wrote persuasive business model pitches with intelligent nudges and adaptive self-evaluation	Machine learning analyzed texts and provided personalized feedback and social nudging based on argumentation quality	Improved quality of argumentation and self-efficacy; enhanced student writing and engagement	Tool enabled more persuasive writing; high technology acceptance and perceived usefulness
Wang ⁽¹⁷⁾	728	University students	Multiple AI tools (Generative AI, Personalized Learning Systems, Intelligent Tutoring Systems)	Development and application of a scale measuring perceived interactivity of learner-AI interaction; 17-item scale applied to students using various AI tools	Adaptive feedback and learning control assessed via personalization and responsiveness dimensions of the scale	Higher perceived interactivity linked to behavioral intention to use AI and longer usage duration	Scale validated with high reliability; perceived interactivity was significantly associated with AI tool type, learning engagement, and autonomy
Weber ⁽¹⁸⁾	43	Law students	LegalWriter (ML-based hybrid intelligence learning environment)	Experimental group received formative feedback via LegalWriter AI system in a 5-week writing course	AI highlighted individual writing errors and offered personalized improvement suggestions using fine-tuned BERT models	Higher scores in structured writing and total legal text quality in experimental group; enhanced self-regulated learning and self-efficacy	Significant improvement in structured writing ($p = 0,002$); LegalWriter facilitated deeper engagement and learning autonomy
Xu ⁽¹⁹⁾	200 (planned)	Undergraduate students	Intelligent Tutoring Systems (ITS)	Proposed action research using ITS in experimental group with pre/post testing and interviews over 6 months	Customized learning modules and quizzes aligned with students' progress and learning styles	Anticipated improvement in memory, critical thinking, and problem-solving	Research design supports investigating ITS effects on cognitive development in higher education
Yin ⁽²⁰⁾	99	First-year university students	Chatbot-based micro-learning system	Quasi-experiment comparing chatbot-based micro-learning vs. traditional class for number system conversion	Self-paced chatbot interaction with micro-learning content and personalized feedback	Higher intrinsic motivation, engagement, and value perception in chatbot group	Chatbot learning comparable in performance with added motivational benefits and reduced learning pressure

The emergence of studies from both high-income and upper-middle-income countries further indicates that interest in adaptive systems transcends economic boundaries, driven by a shared need to improve student outcomes and personalize instruction. Although representation from European regions exists, it remains limited, highlighting potential disparities in research output or differing adoption rates of adaptive technologies in higher education contexts (figure 2).

DISCUSSION

Since the aim of this study was to explore how adaptive learning systems based on AI have been implemented in e-learning platforms and what impact they have had on learning, a scoping review was selected as the central methodological approach. Unlike traditional systematic reviews, which focus on answering narrowly defined questions and evaluating the effectiveness of specific interventions, a scoping review allows for a comprehensive and structured mapping of a heterogeneous body of literature. This approach is particularly useful when the field of study is emerging, interdisciplinary, or not yet well established.

The adoption of a scoping review was considered appropriate for identifying the types of adaptive AI-based e-learning platforms currently in use, exploring the various implementation strategies reported in the literature, examining the diverse impacts these systems have had on learning in higher education contexts, and uncovering existing research gaps and areas in need of further investigation.

Moreover, the lack of contributions from regions such as Latin America and Sub-Saharan Africa underscores a geographical research gap, which may be influenced by unequal access to technological infrastructure, funding limitations, or differing educational priorities. This uneven distribution raises questions about the global inclusivity of current evidence and the generalizability of findings, pointing to the need for broader international engagement in future investigations.

The findings of this systematic review highlighted several key implications regarding the implementation and effectiveness of adaptive learning platforms in higher education. The consistent improvements observed in academic performance and student engagement across diverse educational contexts suggested that personalized learning experiences provided by adaptive technologies effectively addressed individual student needs. These outcomes were potentially attributed to adaptive systems' capacity to tailor educational content dynamically, offer real-time feedback, and adapt instructional strategies based on learners' performance, thereby enhancing both knowledge retention and overall academic achievement. The results of the present study were consistent with previous research demonstrating significant improvements in academic performance through the use of adaptive learning systems. Notable increases in post-intervention assessment scores had been reported in earlier studies,^(21,22) and similar patterns were observed in this research, as students who engaged with adaptive platforms consistently outperformed those exposed to traditional methods. As also noted by Sari et al.⁽²²⁾ higher course completion rates and increased student engagement were recorded, as reflected in the interaction metrics within the virtual learning environment.

Moreover, the heightened student satisfaction and motivation reported in multiple studies indicated that adaptive learning interventions not only impacted measurable academic outcomes but also positively influenced learner attitudes and perceptions toward the educational process. The significant improvements in student engagement and enjoyment likely resulted from the interactive, immersive, and personalized nature of these platforms, which fostered deeper learner involvement and emotional investment in the learning tasks.

Findings regarding student satisfaction supported observations from prior investigations. As reported by Andhika et al.⁽²¹⁾ and Tang et al.⁽²³⁾ students positively evaluated personalized learning paths and immediate feedback elements that, in the present study, were likewise identified as factors enhancing motivation. Furthermore, consistent with the results of Magaña et al.⁽²⁴⁾ it was found that adaptive learning models in hybrid contexts accommodated diverse learning styles, contributing to greater student engagement and overall satisfaction.

Despite the benefits, several challenges previously reported in the literature were confirmed in this study. Similar to the findings of Ginting et al.⁽²⁵⁾ and Sari et al.⁽²²⁾ persistent barriers such as faculty resistance, technological limitations, and the need for appropriate instructional design were encountered. These obstacles were found to hinder the full implementation of adaptive learning systems in higher education settings and should be addressed to maximize their potential.

It was observed that adaptive learning systems dynamically adjusted content in response to learners' abilities and knowledge levels, thereby promoting individualized pacing and feedback, as previously reported by Er-Radi et al.⁽²⁶⁾ These systems were found to be rooted in constructivist and socio-cultural learning theories, aligning with prior findings that emphasized the importance of differentiated instruction to address the needs of diverse student populations.⁽²⁷⁾ In the present study, such theoretical alignment was corroborated through the qualitative synthesis of adaptive interventions, which reinforced the pedagogical foundations centered on personalization and learner-centered approaches. Real-time feedback mechanisms and personalized learning pathways consistently emerged as essential features that facilitated meaningful educational interactions,

supporting the notion that the instructional design of adaptive systems should integrate these core components.

Previous studies indicated that adaptive learning environments contributed to improved academic outcomes among underserved student groups, fostering greater engagement and confidence.⁽²⁷⁾ Similar patterns were identified in this study, where adaptive technologies were associated with enhanced motivation and higher levels of knowledge retention. Consistent with the findings of Ejjami⁽²⁸⁾ the integration of artificial intelligence within adaptive learning systems was recognized as a scalable strategy capable of delivering equitable learning experiences across various educational contexts.

While the benefits of adaptive learning were reaffirmed, this study also acknowledged concerns highlighted in earlier research regarding ethical implications. Issues related to data privacy, algorithmic fairness, and the risk of embedded biases in AI systems, as discussed by Ejjami⁽²⁸⁾ were recognized as critical considerations. These findings emphasized the need for responsible design and governance to ensure that adaptive learning technologies support equitable access and outcomes for all learners.

Some considerations were acknowledged in this systematic review. The included studies were distributed unevenly across regions, with certain countries being more prominently represented than others, which may have influenced the diversity of perspectives. While this limited geographic scope might constrain the generalizability of findings, the selected studies still provided valuable insights into the implementation of adaptive AI technologies in higher education. Additionally, variations in study design, sample size, and evaluation metrics introduced a degree of heterogeneity that made direct comparisons challenging. The absence of long-term follow-up in many studies also limited conclusions about the durability of observed impacts. Moreover, reliance on self-reported data in some cases could have introduced bias. Despite these factors, the overall consistency of positive findings across contexts supported the reliability and relevance of the synthesized results.

Despite these limitations, the study offered several significant benefits and highlighted the pertinence of investigating adaptive e-learning platforms in higher education. It contributed to a growing body of evidence supporting the potential of AI enhanced education to address individual learning needs, promote engagement, and optimize learning outcomes. The review identified critical design and implementation factors, such as real-time feedback, content personalization, and curriculum alignment, that were consistently associated with positive results.

The pertinence of this research lay in its focus on scalable, flexible, and learner-centered technologies that can support the increasing demand for personalized education in digital environments. As higher education institutions globally continue to adapt to technological and pedagogical transformations, the insights derived from this study serve as a valuable foundation for informed decision making and further innovation. Continued exploration and refinement of adaptive learning systems will be essential to ensuring equitable and effective digital education in diverse educational landscapes.

CONCLUSIONS

This systematic review fulfilled its objective of exploring the implementation of e-learning platforms incorporating adaptive artificial intelligence that autonomously adjust educational content and learning pace based on student progress in higher education. The evidence synthesized across the included studies demonstrated that such systems were successfully integrated into diverse academic fields and cultural contexts, supporting their growing role in digitally enhanced higher education.

The findings indicated that adaptive AI-driven platforms consistently improved students' academic performance, engagement, motivation, and satisfaction. These outcomes supported the conclusion that adaptive systems effectively addressed learner variability by delivering personalized and dynamically adjusted learning experiences. Moreover, the implementation of real-time feedback and performance-based content adaptation emerged as critical mechanisms facilitating these benefits.

The review also highlighted that the success of these platforms depended not only on their technical design but also on institutional readiness, curricular alignment, and user acceptance. Where supportive infrastructure and pedagogical coherence were present, adaptive e-learning tools significantly enhanced the quality and outcomes of instruction.

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