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A Systematic Literature Review of Artificial Intelligence (AI) and Academic Performance in Higher Education

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ABSTRACT

Artificial intelligence (AI) is increasingly embedded in higher education, with growing interest in its effects on students' academic performance. Despite its rapid adoption, evidence regarding its benefits, risks, and implementation conditions remains limited. This systematic literature review synthesizes recent empirical evidence on the impact of AI on academic performance in higher education, and identifies the key opportunities and challenges associated with AI integration. Following the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidelines, a systematic search of the Scopus database was conducted for English language open-access journal articles published between 2023 and 2025. Using predefined inclusion criteria, 3,344 records were screened, resulting in 20 eligible studies for qualitative synthesis. Data were analyzed thematically across methodologies, contexts, and outcomes. The findings indicate that AI positively influences academic performance primarily through enhanced engagement, personalization, predictive analytics, and self-efficacy. Predictive models have achieved high accuracy in identifying at-risk students and supporting early intervention. However, challenges, including AI dependency, academic integrity concerns, data privacy risks, and unequal benefits across student groups, have consistently been reported. AI has substantial potential to enhance academic performance in higher education, but its effectiveness depends on thoughtful pedagogical integration, institutional readiness, and ethical governance. Balanced, inclusive, and well-regulated AI adoption is essential for maximizing benefits while mitigating risks.

INTRODUCTION

Artificial Intelligence (AI) fundamentally transforms the landscape of higher education, offering unprecedented opportunities to enhance academic performance and learning experiences (Benchallal, 2025; Jaboob *et al.*, 2025). The integration of AI technologies has demonstrated significant potential in personalizing learning, improving educational outcomes, and supporting both students and educators (AL-Sammarraie, 2025; Benchallal, 2025).

Recent systematic reviews have revealed that AI applications in higher education span multiple domains including predictive analytics, adaptive learning systems, and intelligent tutoring platforms (Atmasani *et al.* 2025; Aguado-García *et al.* 2025). These technologies can enhance learning efficiency, strengthen conceptual understanding, and support student creativity and problem-solving skills (Henukh *et al.*, 2025; Jaboob *et al.*, 2025).

AI helps students learn more effectively and improves their academic performance through personalized learning tailored to individual needs (Hanaysha *et al.*, 2023). The ability to personalize education allows students to access materials and activities tailored to their specific preferences and needs (Barvinski *et al.*, 2019). Furthermore, student performance is better when education is personalized because it allows us to discover individual characteristics and group students (Díaz-Serrano *et al.*, 2022). The successful implementation of AI in higher education requires careful planning and adequate training of the educational personnel (Pacheco-Mendoza *et al.*, 2023). It is crucial that teachers adapt to new technological advances and learn how to integrate them effectively into their teaching methods (Wang, 2023).

However, the rapid adoption of AI is not without significant challenges. Ethical concerns regarding academic integrity, data privacy, and potential technological dependency have emerged as critical considerations (Hidayatullah *et al.*, 2025; Madwe *et al.*, 2025). Researchers have identified risks, such as potential plagiarism, dissemination of inaccurate information, and potential degradation of critical thinking skills (Atmasani *et al.*, 2025; Guo & Zaini, 2024). Moreover, the potential risk of overreliance on AI technologies cannot be overlooked. Research indicates that excessive AI integration might impede critical thinking, suppress creativity, and compromise academic integrity (Cui & Alias, 2024; Khatri & Karki, 2023).

Existing literature demonstrates both promising opportunities and substantial limitations in AI integration. While AI tools can improve writing quality, provide personalized feedback, and support research processes (Hidayatullah *et al.*, 2025; Guo & Zaini, 2024), there remain significant gaps in understanding their long-term pedagogical impact (Henukh *et al.*, 2025).

Institutional readiness and technological infrastructure present additional challenges for effective AI

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implementation (AL-Sammarraie, 2025). Multiple studies have consistently highlighted the need for comprehensive digital literacy training and robust ethical frameworks (Benchallal, 2025; Erlangga & Magdalena, 2025).

Recognizing these complex dynamics, this study aimed to address two critical research questions: (RQ1) What are the primary effects of AI on academic performance in higher education? (RQ2) What are the key challenges and opportunities associated with AI integration in the academic context?

By systematically examining SCOPUS-indexed studies, this study seeks to provide a comprehensive overview of AI's role of AI in higher education, offering insights for educators, policymakers, and researchers navigating the evolving technological landscape (Atmasani *et al.*, 2025; Henukh *et al.*, 2025).

MATERIALS AND METHODS

This systematic review amalgamates and synthesizes various research studies to address two research questions, employing the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) methodology (Ferretti *et al.*, 2021; Jacob *et al.*, 2023).

Eligibility criteria

This literature review covers studies on 'artificial intelligence (AI),' 'academic performance,' and 'higher education.' The selection criteria for literature included only research articles written in English and published between 2023 and 2025. Records that did not meet the inclusion criteria were excluded.

Information sources and search strategy

During the identification stage of PRISMA, bibliographic searches were conducted using the Scopus database. We crafted a search strategy for this systematic search to locate pertinent literature. This search strategy was tailored to Scopus databases, and the search terms used were the following TITLE-ABS-KEY ("artificial intelligence" OR "AI" OR "machine learning" OR "deep learning" OR "generative AI") AND ("academic performance" OR "learning outcomes" OR "student achievement" OR "academic achievement") AND ("higher education" OR "university" OR "universities" OR "college" OR "tertiary education").

Study selection and exclusion criteria

To ensure consistency and accuracy, we conducted a systematic search using the following search string: ("artificial intelligence" OR "AI" OR "machine learning" OR "deep learning" OR "generative AI") AND ("academic performance" OR "learning outcomes" OR "student achievement" OR "academic achievement") AND ("higher education" OR "university" OR "universities" OR "college" OR "tertiary education"). The search yielded 3,344 documents. We subsequently refined our search strategy by applying the following filters: 'open access, ' 'year range 2023-2025,' 'document type article, ' 'final publication stage,' keywords: 'artificial intelligence, ' 'academic performance,' 'higher education,' and language: English, resulting in 445 records. No duplicate records were identified during this process. We then compiled a comprehensive evaluation/checklist containing various details such as study titles and abstracts, which were identified and screened for eligibility (n = 445). A total of 285 records were excluded based on title and abstract screening, resulting in an appraisal of 160 full-text articles. Subsequently, 140 records were excluded as they did not meet the inclusion criteria. This left 20 records for eligibility assessment. Figure 1 illustrates the use of the PRISMA framework to visually represent the process of including and excluding studies in each stage

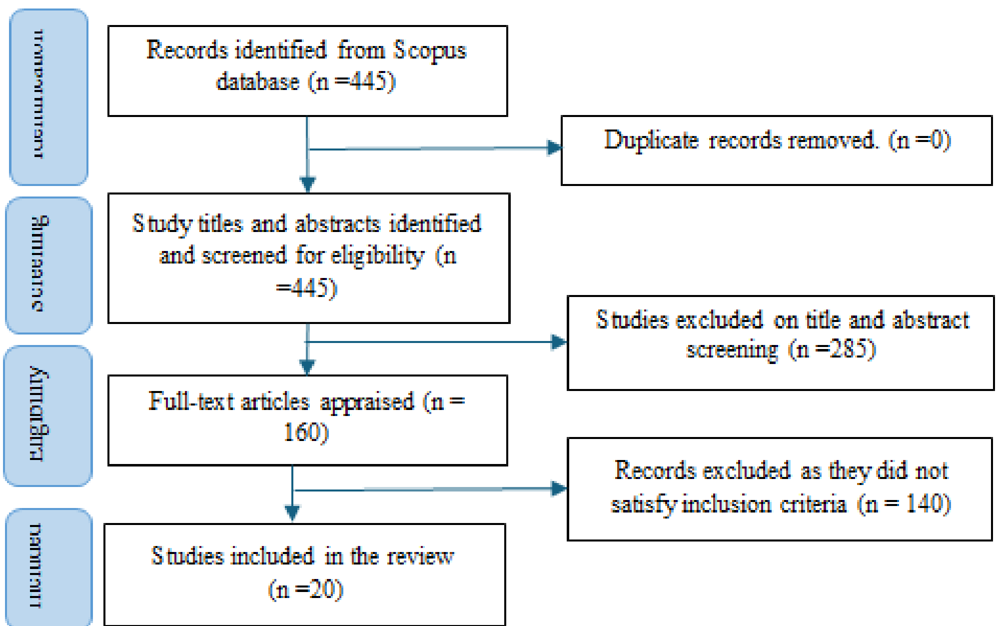

Figure 1: The process of literature review.

of the review.

RESULTS AND DISCUSSION

Documents by year

Figure 2 illustrates a marked and rapid increase in Scopus-indexed publications concerning artificial intelligence and academic performance in higher education from 2023 to 2025. Research output experiences a significant rise from 2023 to 2024, followed by more than doubling by 2025, signifying a pronounced acceleration in scholarly interest during this timeframe. This upward trajectory reflects the growing integration of AI technologies in higher education, and the increasing need to empirically investigate their effects on student learning and academic outcomes. Overall, the pattern suggests that the field is undergoing a phase of rapid expansion, with 2025 representing a peak in research activity within the review period.

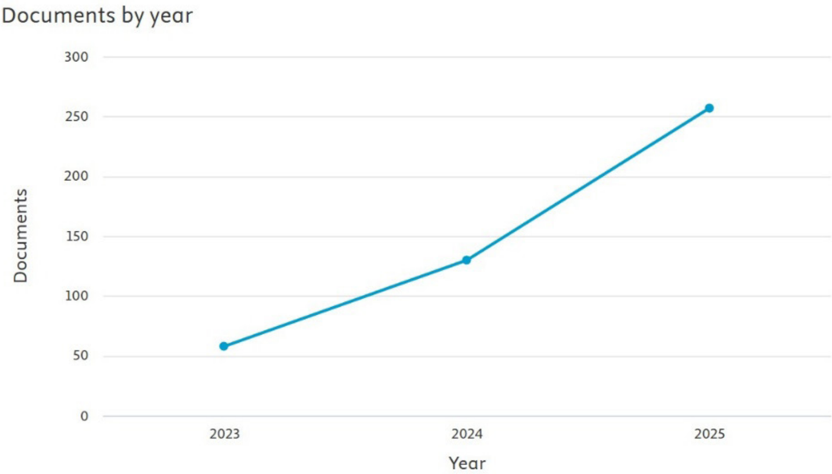

Figure 2: Documents by year

Documents by subject area

Figure 3 illustrates the distribution of the research documents across various academic disciplines. Research on artificial intelligence and academic performance in higher education is predominantly concentrated in Social Sciences (29.9%) and Computer Science (24.2%), highlighting the foundational roles of pedagogical and technological perspectives in this body of literature. Contributions from Engineering (7.3%) and psychology (5.0%) were moderate, indicating growing interest in system design and learner-centered cognitive outcomes. Multidisciplinary research (4.7%) further emphasizes cross-disciplinary engagement, whereas smaller contributions from Materials Science, Business and Management, Health Professions, Medicine, and Environmental Sciences suggest limited but emerging applications of AI in educational contexts. The significant proportion categorized as "Other" (14.6%) underscores the diffusion of this research topic across diverse academic domains, reinforcing its interdisciplinary nature within higher education scholarship.

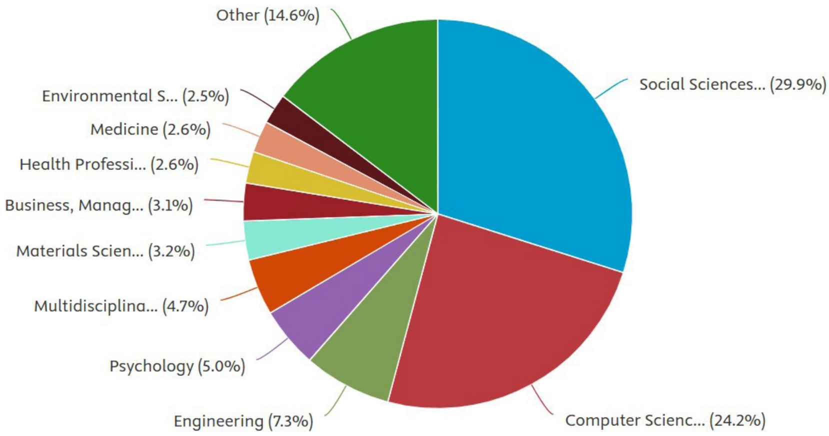

Figure 3: Documents by subject area

Documents by affiliation

Figure 4 illustrates that the research output is concentrated among a selected group of leading institutions, with Tecnológico de Monterrey identified as the most prolific, producing approximately nine documents. This was followed by King Faisal University and CQ University in Australia. A secondary cluster, comprising The University of Hong Kong, King Saud University, and Ajman University, demonstrates moderate yet comparable levels of scholarly contributions. Other institutions, including the University of Johannesburg, King Abdulaziz University, Vellore Institute of Technology, and Universidad Rey Juan Carlos, contributed similar, albeit slightly lower, numbers of publications. Overall, the data suggest that scholarly production in this domain is predominantly concentrated within a limited number of universities, whereas contributions from other institutions are distributed more evenly at lower levels.

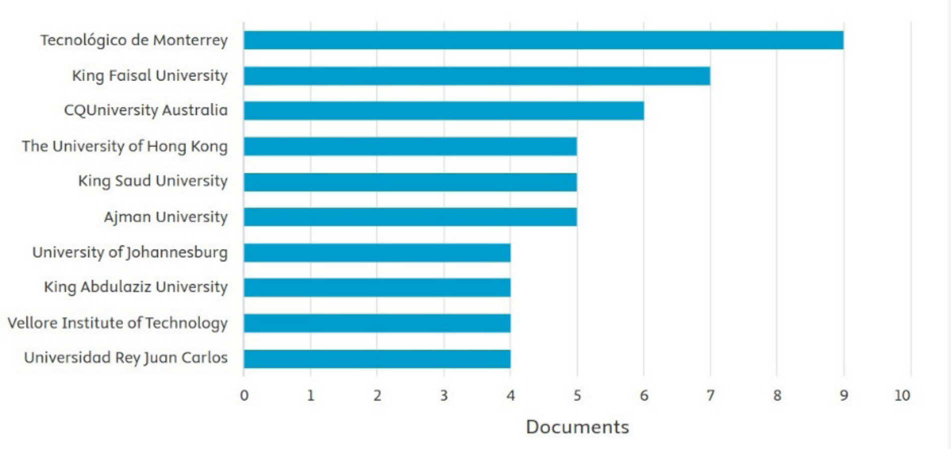

Figure 4: Documents by affiliation

Documents by country

Figure 5 illustrates the contributions of various countries to the domain of artificial intelligence (AI) in higher education. China has emerged as a leading contributor, generating approximately 70 documents. The United States has an output of approximately 40–45 documents. In the intermediate range, Saudi Arabia and Spain each contribute to the low-to-mid 30s, whereas Malaysia produces approximately 20–25 documents. Australia, the United Kingdom, India, and Pakistan each contributed to the high teens, with Peru being the smallest contributor, producing around mid-teens. Overall, the majority of research output is concentrated in China and the United States, with other countries making moderate yet noticeably smaller contributions.

This section, as shown in Table 1, summarizes

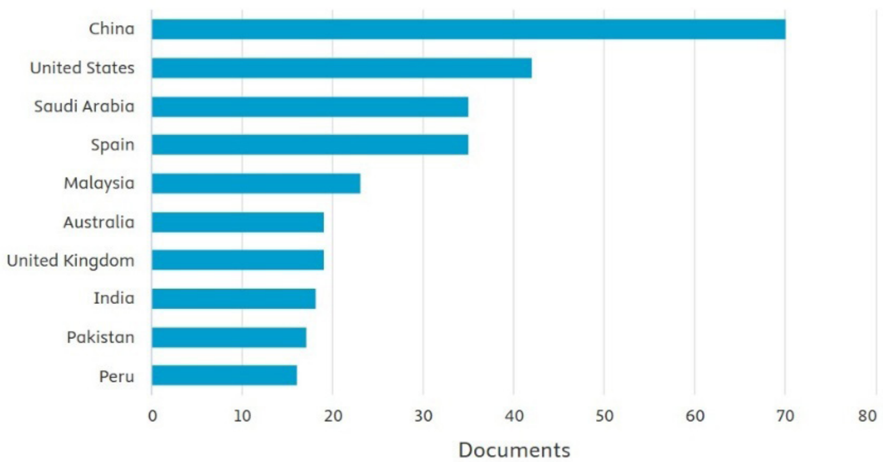

Figure 5: Documents by country or territory

the objectives, methodologies, key findings, and recommendations of the 20 selected papers on the effect of Artificial Intelligence (AI) on Academic Performance in Higher Education from 2023 to 2025.

A comprehensive analysis of these studies revealed several convergent themes regarding AI's multifaceted impact on academic performance in higher education. Predictive analytics has emerged as a dominant application, with AI demonstrating remarkable forecasting capabilities ranging from 85-90% accuracy in general contexts to 93.35% accuracy using Gradient Boosting algorithms for STEM student outcomes, thereby enabling proactive early intervention strategies (Messele, 2025). Across diverse geographic contexts spanning Peru, Pakistan, Ghana, China, Austria, Malaysia, and England, AI-powered tools consistently enhance student engagement, critical thinking abilities, and academic achievement, with students' perceptions of AI technologies explaining up to 40.4% of the variance in academic performance when mediated by engagement factors (Drydakis, 2025;

Table 1: A content review of the selected articles

References	Title	Aims/ objectives	Methodology	Key findings	Recommendations
(Chaudhry *et al.*, 2023)	Time to Revisit Existing Student's Performance Evaluation Approach in Higher Education Sector in a New Era of ChatGPT — A Case Study	Evaluate ChatGPT's ability to complete undergraduate assessments and test AI-detection tools.	Quasi-experimental comparison between ChatGPT outputs and top student submissions; AI-detection tools applied.	ChatGPT often matched or outperformed students; detection tools were unreliable.	Redesign assessments; update academic integrity policies; train faculty on AI-aware evaluation.
(Pacheco-Mendoza *et al.*, 2023)	Artificial Intelligence in Higher Education: A Predictive Model for Academic Performance	Develop a predictive model of academic performance using AI-related variables.	Quantitative survey; multiple linear regression analysis.	AI-use variables significantly predicted academic performance ($R^2 \approx 0.91$).	Use predictive models for early student support; validate across contexts.
(Cacheda *et al.*, 2024)	Data-Driven Early Academic Intervention: Harnessing AI for Students Achievement	Detect at-risk students early using AI-based predictive models.	Machine learning with time-aware features from coursework data.	Over 90% accuracy in mid-course predictions.	Adopt early-warning systems with human intervention.
(Eltahir & Babiker, 2024)	The Influence of Artificial Intelligence Tools on Student Performance in e-Learning Environments: Case Study	Assess impact of AI tools on pre-service teachers' performance.	Quasi-experimental with control and experimental groups.	AI-supported students showed higher achievement and engagement.	Integrate AI tools with training and ethical oversight.
(Dahri *et al.*, 2024)	Investigating AI-based academic support acceptance and its impact on students' performance in Malaysian and Pakistani higher education institutions	Examine AI academic support acceptance and outcomes.	Survey-based PLS-SEM using UTAUT model.	AI adoption improved satisfaction and learning outcomes.	Focus on pedagogical fit and institutional support.
(Youssef *et al.*, 2024)	Examining the effect of ChatGPT usage on students' academic learning and achievement: A survey-based study in Ajman, UAE	Examine the effect of ChatGPT usage on student engagement, critical thinking, and academic achievement in UAE higher education.	Quantitative cross-sectional survey (n=353); Constructivist Theory; PLS-SEM.	ChatGPT usage positively influenced engagement, critical thinking, and academic achievement.	Use ChatGPT as a supplementary learning tool; establish ethical guidelines; conduct longitudinal studies.

(Nurtanto *et al.*, 2025)	Determinants of behavioral intentions and their impact on student performance in the use of AI technology in higher education in Indonesia: A SEM-PLS analysis based on TPB, UTAUT, and TAM frameworks	Identify determinants of AI usage intention and their impact on academic performance in Indonesia.	quantitative survey; ex post facto design with a survey-based online questionnaire method (n=2894); PLS-SEM.	Attitude, performance expectancy, and facilitating conditions improved performance; perceived risk reduced outcomes.	Reduce AI anxiety, strengthen institutional support, redesign curricula, and promote responsible AI use.
(Revesai, 2025)	Generative AI dependency: the emerging academic crisis and its impact on student performance—a case study of a university in Zimbabwe	Investigate generative AI dependency and its impact on student academic performance in Zimbabwe.	A Sequential Mixed method: surveys, interviews, usage tracking, and GPA analysis (n=248).	AI dependency significantly reduced GPA, critical thinking, writing skills, and content knowledge.	Introduce AI-use regulations, promote balanced use, and strengthen academic skills training.
(Lozano-Gomez & Fernando Libaque-Saenz, 2025)	The impact of AI tools on undergraduate students' academic performance: A case study of Peru	Assess the impact of ChatGPT usage patterns on undergraduate academic performance in Peru.	Quantitative survey (n=263); PLS-SEM.	Idea generation improved performance; research-support usage negatively affected outcomes.	Improve AI literacy, emphasize verification, and guide task-appropriate AI use.
(Haron *et al.*, 2024)	An Artificial Intelligence Approach to Monitor and Predict Student Academic Performance	Develop an AI-based system to monitor and predict student academic performance in Malaysia.	Mixed methods; academic-record data; machine learning (RepTree, k-NN, Naïve Bayes).	RepTree achieved the highest prediction accuracy and effectively identified at-risk students.	Adopt RepTree-based monitoring systems and enable early academic intervention.
(Phua *et al.*, 2025)	Evaluating the Impact of Artificial Intelligence Tools on Enhancing Student Academic Performance: Efficacy Amidst Security and Privacy Concerns	Examine factors influencing students' adoption and use of AI tools in higher education.	Quantitative; Survey (n=202); validated measures; PLS-SEM and regression analysis.	Perceived usefulness, ease of use, and security increased intention; intention predicted actual use.	Enhance AI usability, privacy safeguards, and student AI-literacy training.
(Dahri *et al.*, 2025)	Enhancing Mobile Learning with AI-Powered Chatbots: Investigating ChatGPT's Impact on Student Engagement and Academic Performance	Assess the impact of mobile ChatGPT use on engagement and academic performance.	Quantitative; Quasi-experimental design; experimental vs control groups; ANCOVA.	ChatGPT improved academic performance, motivation, trust, and reduced cognitive load.	Integrate AI chatbots into mobile learning with instructor guidance.

(Wei *et al.*, 2025)	The Dual Impact of AI Adoption on College Students' Academic Performance in Music Education: Evidence from China	Explore effects of AI literacy on self-efficacy, AI output quality, and performance.	Quantitative survey; CFA and SEM.	AI literacy improved self-efficacy and output quality but not academic performance.	Combine AI-literacy training with pedagogical and assessment reforms.
(Bećirović *et al.*, 2025)	Exploring students' AI literacy and its effects on their AI output quality, self-efficacy, and academic performance	Examine relationships between AI-literacy dimensions and learning outcomes.	Quantitative survey (n=286); Structural equation modelling with SPSS and AMOS softwire packages.	Technical understanding and practical application supported self-efficacy; no direct grade impact.	Provide structured AI guidance and redesign assessments.
(Ashraf *et al.*, 2025)	Effects of ChatGPT on students' academic performance in Pakistan higher education classrooms	Investigate ChatGPT use and its effect on academic performance in Pakistan.	Quantitative descriptive approach survey (352); extended PLS-SEM with SmartPLS4.	Behavioral intention and habit positively influenced academic performance.	Develop institutional AI-use policies and faculty training.
(Acquah *et al.*, 2025)	Modelling economics students' use of ChatGPT and academic performance: insights from self determination theory and epistemic curiosity	Examine how ChatGPT use shapes economics students' motivation, self-efficacy, belief about the future and perceived academic performance; test how ICAP and SDT factors interact and whether epistemic curiosity moderates effects.	A descriptive cross-sectional survey design; quantitative modelling using PLS-SEM and fuzzy-set qualitative comparative analysis (fsQCA).	ChatGPT use positively links to desire to learn, self-efficacy and future beliefs; perceptions predict engagement and perceived performance. Epistemic curiosity negatively moderated some benefits (diminishing returns). fsQCA showed self-efficacy can alone drive success in some configurations.	Design AI interventions that support intrinsic motivation and active engagement; faculty training on integrating ChatGPT; assessment recalibration to avoid overconfidence; mentoring/ workshops to build self-efficacy and maintain curiosity.

(Fan *et al.*, 2025)	Educational impacts of generative artificial intelligence on learning and performance of engineering students in China	Explore frequency, scenarios, impacts, challenges and student expectations for generative AI use in Chinese engineering education.	A quantitative; an anonymized questionnaire survey (n = 148) combining 21 scale items, multiple-choice items and one open question; descriptive and inferential analysis.	Majority report generative AI improves learning efficiency, initiative and creativity; about half report improved independent thinking. Many reported no clear change in formal academic performance; main concerns were content accuracy, domain reliability, over-reliance, usability, cost and ethics. Strong support for regulated, tailored integration (partial integration preferred).	Provide clear university guidelines; offer basic and advanced AI training for students and faculty; integrate AI modules tailored by discipline; improve tool accuracy and domain-specific capabilities; adopt phased, policy-backed integration.
(Mehrvarz *et al.*, 2025)	How does students' perception of ChatGPT shape online learning engagement and performance?	Test whether students' perceptions of ChatGPT predict online learning engagement and academic performance, and whether engagement mediates that relationship.	Cross-sectional survey of graduate students (n = 305, Shiraz University); validated multi-item scales; Structural Equation Modeling (SEM) with bootstrapped mediation analysis.	Perception → engagement (β = 0.438); engagement → academic performance (β = 0.470); perception → performance (direct β = 0.268; indirect via engagement β = 0.206). Perception explains ~19.2% of engagement variance; perception + engagement explain ~40.4% of performance variance. Good model fit and significant mediation by engagement.	Leverage positive perceptions by designing ChatGPT-supported activities that boost engagement; embed AI tasks that require active use (not passive copying); train students and staff on ethical use and prompt design; build safeguards against over-reliance and align assessment to AI-augmented workflows.

(Messele, 2025)	Ensemble machine learning for predicting academic performance in STEM education	Build predictive models for STEM students' academic outcomes and identify the strongest predictors to guide interventions and policy.	The design science research methodology; Secondary datasets from three Ethiopian universities; large sample (≈18,274 records) with 16 features; data cleaning, feature selection, train/test split (80/20); tested ensemble algorithms (Gradient Boosting, XGBoost, CatBoost, Random Forest) plus baseline classifiers; evaluated accuracy, precision, recall, F1.	Gradient Boosting (without class decomposition) performed best (accuracy 93.35%, precision 92.69%, recall 93.14%, F1 92.90%). Key predictors included transcripts, department, wealth index, parental education/occupation, student/parent ages, region, residence, internship, credit hours, entrance exam scores, and admission type.	Use predictive models to flag at-risk students and target interventions; consider richer features (LMS logs, study habits, mental health, motivation) in future models; explore deep learning extensions and monitor fairness across groups.
(Drydakis, 2025)	The formation of AI Capital in higher education: Enhancing students' academic performance and employment rates	Develop and validate the "AI Capital of Students" scale; evaluate a 12-week AI module's effect on AI Capital, academic performance, and employment outcomes (6-month follow-up).	Scale development (DeVellis framework), longitudinal intervention (AI in Business Environments module delivered 4 times, 2023–24); pre/post measures including a 120-question AI test, module grades; statistical analysis with Random Effects, OLS, Probit for employment, and robustness checks.	AI training produced large, statistically significant increases in AI Capital scores, test scores and module grades. AI Capital correlates positively with module grades and with higher employment rates six months post-graduation. However, gaps persist: male and White students and those with strong prior quantitative backgrounds scored higher.	Embed inclusive AI modules across curricula; use the validated AI Capital scale to monitor progress; provide targeted support for underrepresented groups (bridging courses, hands-on labs); design equitable assessment and employer signaling (certificates/badges) to translate AI Capital into employability.

Fan *et al.*, 2025; Mehrvarz *et al.*, 2025). Psychological mediating factors, including self-efficacy, motivation, epistemic curiosity, and technology acceptance, such as performance expectancy and institutional support, have emerged as crucial determinants of successful AI integration. However, the research simultaneously uncovered significant implementation challenges, including AI dependency concerns affecting 32.7% of students; assessment integrity issues necessitating revised evaluation methodologies; data privacy and security considerations; and persistent equity disparities favoring male students, white students, and those with stronger mathematical backgrounds (Drydakis, 2025; Fan *et al.*, 2025). The findings collectively underscore that while AI holds transformative potential for enhancing educational outcomes through personalized learning, predictive interventions, and capacity building, successful implementation demands careful consideration of dependency risks, institutional readiness, pedagogical strategies, and targeted support mechanisms to ensure equitable benefits across diverse student populations.

Discussion

This systematic review aimed to synthesize SCOPUS-indexed evidence (2023–2025) on how artificial intelligence (AI) affects academic performance in higher education. Across geographic regions, methodologies, and disciplinary settings, a consistent picture emerges: AI is neither a panacea nor hazard. Instead, it acts as a powerful educational amplifier whose effects depend critically on pedagogy, institutional readiness, and students' psychological and sociodemographic contexts. Below, I explain what the findings mean, why they likely occurred, the implications for policy and practice, concrete recommendations, important gaps that remain, and the limitations of the current evidence base.

AI works — consistently — as an engagement and performance amplifier when integrated thoughtfully

A dominant cross-cutting theme across the sampled studies is that AI tools, ranging from predictive analytics and adaptive tutors to generative systems such as ChatGPT, are associated with measurable improvements in indicators linked to academic success: engagement, clearer conceptual understanding, self-reported learning gains, and (in many studies) improved grades or scores. For example, studies using structural equation modeling have reported that students' perceptions of ChatGPT and related generative tools explain a substantial share of the variance in academic outcomes when that perception increases online learning engagement (combined $R^2 \approx 0.404$) (Mehrvarz *et al.*, 2025). This was confirmed in experimental/quasi-experimental work showing improved post-test scores and reduced cognitive load after short-scaffolded AI interventions (Drydakis, 2025).

Predictive analytics is an especially robust application

Predictive modeling and ensemble machine learning showed high accuracy for forecasting student outcomes (reported accuracies in this corpus ranged from approximately 85 to 90% in general predictive contexts to a peak of ~93.35% using Gradient Boosting for STEM outcomes). These results demonstrate that administrative and pedagogical stakeholders can identify at-risk students early and allocate support proactively (Messele, 2025).

Psychological and contextual mediators determine who benefits

The literature repeatedly points to the following mediating variables: self-efficacy, epistemic curiosity, motivation, forms of engagement (behavioral, cognitive, and emotional), and technology-acceptance constructs (performance expectancy, perceived ease of use, and facilitating conditions). These variables explain why identical AI tools produce different outcomes across student groups and contexts. For instance, increased AI literacy and self-efficacy translate into higher-quality AI outputs and (in some studies) better academic results, whereas higher concerns or low digital confidence blunt benefits (Bećirović *et al.*, 2025; Mehrvarz *et al.*, 2025).

Risks: dependency, academic integrity, privacy, and inequitable gains

These studies also documented non-trivial risks. Revesai (2025) reported the rates of generative AI dependency patterns (around 32.7% in a sampled setting), with negative associations linked to specific academic skills (e.g., writing practice and critical thinking). Other recurring problems include assessment-integrity challenges, data privacy/security concerns, and persistent equity gaps (male/white students and those with stronger mathematics backgrounds often gain more from AI educational interventions) (Drydakis, 2025).

Why these results likely occurred (mechanisms & theory)

Cognitive scaffolding, immediate feedback, and personalization

AI tools provide rapid, individualized feedback and scaffold complex tasks into manageable steps. The Technology Acceptance Model, social cognitive theory (self-efficacy), and ICAP engagement frameworks explain why when students receive timely, actionable feedback and feel competent using the tools, they adopt more constructive and interactive learning behaviors that foster deeper processing and retention. This mechanism is explicitly supported by SEM and experimental data from the reviewed corpus (Drydakis, 2025; Mehrvarz *et al.*, 2025).

Predictive systems enable early, targeted intervention

Predictive analytics aggregates learning management system signals, demographic features, and prior performance to detect risks. When these models are accurate, they enable interventions that would otherwise be reactive and ad-hoc. The high reported accuracies (including Gradient Boosting at ~93%) illustrate that AI can be a reliable early warning system (Messele, 2025).

Institutional scaffolding and pedagogical design shape transfer

AI is an amplifying technology, and its net effect depends on how institutions embed it (curriculum design, teacher development, and inclusive pedagogy). The AI Capital framework clarifies that AI learning yields academic and employability benefits when curricula deliberately build knowledge, skills, and capabilities rather than offering ad hoc tool usage. Where institutions provide scaffolded, inclusive, and experiential AI modules, outcomes are stronger and more equitable (Drydakis, 2025).

Social and structural inequalities produce asymmetric benefit

Students with prior quantitative skills, familiarity with digital tools, or higher socioeconomic resources can leverage AI more effectively. This amplifies existing advantages, unless institutions actively mitigate gaps through preparatory modules, targeted mentoring, and inclusive design (Drydakis, 2025).

Psychological cost and dependency pathways

Dependency appears when AI substitutes for skill practice (e.g., writing and problem formulation) rather than augmenting it. In resource-constrained contexts, students sometimes form "necessity-driven" dependencies — AI use becomes habitual to fill real resource gaps (e.g., poor library access), which later harms skill development when untreated (Revesai, 2025).

Implications

For pedagogy and curriculum, AI tools must be integrated as pedagogical partners rather than task replacers. Course design should use AI to scaffold higher-order tasks (analysis, synthesis, and evaluation), while preserving deliberate practice opportunities for core skills. Embed assignments that require students to explain AI-assisted outputs, critique sources, and show processes, not only products (Drydakis, 2025).

Assessment systems require redesign for assessment and academic integrity. Traditional take-home essays and closed book exams are vulnerable to misuse. The evidence suggests a shift towards diversified assessment portfolios (oral defenses, in-class authentic tasks, process logs, reflective components) and the use of AI detection as part of an academic integrity ecosystem, not as a sole arbiter (Chaudhry *et al.*, 2023).

Institutional investment in instructor development, accessible AI platforms, data governance, and infrastructure is essential for institutional strategy and capacity building. Institutions that purposefully build AI Capital through scaffolded modules produce measurable gains for students (including employment effects) (Drydakis, 2025).

For equity and inclusion, targeted support (bridge courses in quantitative reasoning, mentorship for underrepresented students, and no-code AI tools) is required to prevent AI from widening its achievement gaps. Monitoring and disaggregated reporting will help identify groups at risk of under benefits (Drydakis, 2025). Policies should address data privacy, algorithmic transparency, and ethical AI use in learning analytics and grading. Clear enforceable rules regarding student data rights and model explainability will build trust and reduce misuse risks (Messele, 2025).

Practical recommendations

Educational institutions should strategically develop AI-enhanced curricula that integrate tools with direct instruction in AI literacy, critical analysis, and prompt engineering, following the AI Capital framework. They should implement predictive analytics for early warnings by using highly accurate models supported by human oversight and ethical reviews. Assessment portfolios must be updated to include multimodal, formative, and process-focused methods with oral or collaborative elements. Additionally, scaffolded AI literacy should be provided to all students through introductory courses or micro-credentials that cover quantitative basics, ethics, and tool evaluation. Specific equity initiatives, such as preparatory quantitative courses, peer mentoring, and user-friendly no-code tools should be introduced, with results tracked by gender, ethnicity, and socioeconomic status.

Research gaps

Existing research exhibits several gaps. There is a lack of longitudinal causal studies investigating whether the use of artificial intelligence (AI) results in sustained learning or gradual deterioration of foundational skills. Additionally, systematic research on discipline-specific interactions, particularly in the creative arts, studios, and clinical training, remains insufficient. Furthermore, trial dismantling research has not been adequately conducted to determine which pedagogical elements, such as prompting, feedback timing, and scaffolding, enhance or diminish the effects of educational interventions. Moreover, there is a paucity of evidence from low-resource culturally diverse settings. Finally, comprehensive research in these areas has yet to be conducted.

Limitations of the existing evidence

The limitations of the evidence base and this review include a pronounced sample and regional bias favoring countries and institutions where AI investment is already prevalent, thereby restricting the generalizability of the findings globally. Additionally, reliance on short-term timeframes and cross-sectional designs may lead to an overestimation of immediate benefits while overlooking delayed disadvantages, such as skill atrophy. The use of self-report measures and non-uniform outcomes, as opposed to objective performance metrics, further constrains the robustness of the findings. Moreover, publication and selection biases, exemplified by SCOPUS-indexed results, may disproportionately represent positive outcomes and well-resourced environments and pose significant challenges. Finally, the rapid turnover of tools and vendors complicates the stability of results.

CONCLUSION

The reviewed SCOPUS-indexed evidence (2023–2025) provides a coherent case: AI can substantially enhance student engagement and measurable academic outcomes, especially when embedded in well-designed pedagogies and supported by institutional capacities. Predictive analytics are sufficiently mature to underpin early alert systems, and AI literacy and scaffolded curricular integration predict stronger and more equitable returns. However, benefits are uneven and accompanied by real risks, such as dependency, assessment integrity issues, privacy concerns, and the potential for AI to widen existing inequalities if left unchecked. For higher education to realize AI's promise, institutions must pair technological adoption with intentional pedagogy, inclusive design, robust governance, and continuous evaluation.

Future research in this domain should prioritize longitudinal, multi-site cohort studies that examine academic trajectories and skill retention. These studies should employ de facto or randomized/quasi-experimental dismantling trials to isolate pedagogical variables, such as immediate versus delayed feedback, and AI-assisted drafting versus AI critique, to identify causal mechanisms. Additionally, these investigations should incorporate culturally sensitive interventions.

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