

THE EFFECTIVENESS OF AI-BASED LEARNING AND GAMIFICATION IN ENHANCING ACADEMIC ACHIEVEMENT: A LITERATURE REVIEW

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ABSTRACT

This systematic literature review synthesizes empirical evidence on the effectiveness of AI-based learning and gamification both independently and in combination in improving students' academic achievement. Drawing from 124 peer-reviewed journal articles published between 2021 and 2026 extracted from Scopus, Web of Science, and ERIC databases, the analysis focuses on experimental, quasi-experimental, and meta-analytic studies across primary, secondary, and higher education contexts. Findings reveal that gamification consistently yields moderate-to-large positive effects on achievement (Hedge's $g = 0.79-1.12$), while AI-driven adaptive systems enhance outcomes through personalization (effect sizes $0.40-0.97$). Combined AI-gamification approaches demonstrate the strongest gains by integrating real-time feedback, adaptive difficulty, and motivational game elements (g up to 1.24). Mechanisms include increased engagement, intrinsic motivation, and self-regulated learning. Challenges such as digital equity and over-reliance on extrinsic rewards are noted. The review concludes that integrating AI and gamification offers a scalable, evidence-based pathway to elevate academic achievement, with clear implications for curriculum design and teacher training.

Keywords: *ai-based learning, academic achievement, gamification, literature review, personalized education*

ABSTRAK

Tinjauan pustaka sistematis ini mensintesis bukti empiris tentang efektivitas pembelajaran berbasis AI dan gamifikasi—baik secara independen maupun kombinasi—dalam meningkatkan prestasi akademik siswa. Berdasarkan 124 artikel jurnal peer-review yang terbit antara tahun 2021-2026 dari database Scopus, Web of Science, dan ERIC, analisis difokuskan pada studi eksperimental, kuasi-eksperimental, dan meta-analitik di berbagai jenjang pendidikan. Temuan menunjukkan bahwa gamifikasi secara konsisten menghasilkan efek positif sedang hingga besar (Hedge's $g = 0,79-1,12$), sementara sistem adaptif berbasis AI

meningkatkan hasil melalui personalisasi (effect size 0,40–0,97). Pendekatan kombinasi AI-gamifikasi menunjukkan peningkatan terkuat dengan mengintegrasikan umpan balik real-time, tingkat kesulitan adaptif, dan elemen game motivasional (g hingga 1,24). Mekanismenya mencakup peningkatan keterlibatan, motivasi intrinsik, dan pembelajaran mandiri. Tantangan seperti kesetaraan digital dan ketergantungan berlebihan pada penghargaan ekstrinsik juga dicatat. Tinjauan ini menyimpulkan bahwa integrasi AI dan gamifikasi menawarkan jalur berbasis bukti yang skalabel untuk meningkatkan prestasi akademik.

Kata Kunci: gamifikasi, pendidikan pembelajaran berbasis ai, personalisasi, prestasi akademik, tinjauan pustaka

A. Introduction

The rapid integration of artificial intelligence (AI) and gamification into educational practices has transformed traditional learning paradigms, particularly in the post-pandemic era. AI-based learning systems leverage machine learning for adaptive content delivery, real-time feedback, and predictive analytics, enabling personalized pathways that address individual learner needs (Gu, 2025; Huang et al., 2025; Yunusa & Umar, 2021). Gamification, by incorporating game elements such as points, badges, leaderboards, and challenges into non-game contexts, enhances motivation and engagement (Gómez Niño et al., 2024; Kam & Umar, 2024; Lampropoulos & Sidiropoulos, 2024).

Academic achievement—measured through test scores, retention, and skill mastery—remains

a core indicator of educational success. Prior meta-analyses have established that both approaches independently improve outcomes (Sailer & Homner, 2020; Kulik & Fletcher, 2016), yet their synergistic potential remains underexplored in recent literature. Studies have shown that gamification can improve success rates by 14-39% and excellence rates by 70-130% in higher education (Lampropoulos & Sidiropoulos, 2024; Buenadicha-Mateos et al., 2025). Similarly, AI-driven intelligent tutoring systems have demonstrated mean gains of 5-24 points in post-test scores (Huang et al., 2025; Xu et al., 2026).

This review addresses the gap in understanding the combined effectiveness of AI and gamification by systematically examining studies from 2021-2026, focusing on empirical evidence of effectiveness, underlying

mechanisms, and contextual moderators. The analysis is grounded in self-determination theory (autonomy, competence, relatedness) (Ryan & Deci, 2000) and constructivist learning principles, providing a robust theoretical lens for interpreting findings. Recent systematic reviews have called for more integrated approaches to understanding how AI and gamification can work synergistically (Adi et al., 2026; Information, 2026; Gamarra-Vargas et al., 2026).

B. Research Method

This study employed a systematic literature review (SLR) following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement (Page et al., 2021). A comprehensive search was conducted in November 2025 across three major educational databases: Scopus, Web of Science, and ERIC.

The inclusion criteria were: (1) peer-reviewed journal articles; (2) publication years 2021-2026; (3) explicit focus on AI-based learning, gamification, or their integration; (4) measurement of academic achievement; and (5) empirical

designs (experimental, quasi-experimental, or meta-analytic). A total of 537 initial records were identified. After removing duplicates (n=89) and screening titles and abstracts, 162 full-text articles were assessed for eligibility. Finally, 124 studies met the criteria for in-depth qualitative synthesis, with 68 providing sufficient data for quantitative synthesis.

Data extraction focused on effect sizes, participant demographics, intervention duration, subject domains, and reported outcomes. Study quality was assessed using criteria adapted from the Mixed Methods Appraisal Tool (MMAT). Studies scoring below 3 (n=12) were excluded from quantitative synthesis but retained in qualitative synthesis. Thematic analysis was conducted to identify patterns in effectiveness, mechanisms, and limitations.

C. Results and Discussion

1. Effectiveness of Gamification

Gamification demonstrated consistent positive effects on academic achievement. Longitudinal evidence from Lampropoulos and Sidiropoulos (2024) showed gamified

learning outperforming traditional and online formats in success rates (14-39% improvement), excellence rates (70-130%), and average grades (11-25%) across 1,001 higher education students. Meta-analytic findings corroborated moderate-to-large effects (Hedge's $g = 0.79-1.12$), with stronger outcomes in smaller groups (<100 students) and STEM subjects (Kam & Umar, 2023; Ren et al., 2024; Tatal, 2023).

Non-digital and hybrid gamification also proved effective. Studies reported significant gains in mathematics achievement (Cohen's $d = 0.54$) among secondary students using non-digital gamified tasks (Educational dualism in action, 2025; Unleashing gamification, 2025). Mechanisms included heightened intrinsic motivation, flow state, and peer collaboration (Balci & Morris, 2026; Gao et al., 2026; Kam & Umar, 2024).

2. Effectiveness of AI-Based Learning

AI driven interventions enhanced achievement through personalization and adaptive scaffolding. Gu (2025) demonstrated that stacked ensemble deep neural networks with fuzzy feature selection improved prediction

accuracy and subsequent academic achievement. Huang et al. (2025) conducted a meta-analysis of intelligent tutoring systems, finding significant positive effects on learning attitudes, knowledge acquisition, and performance, with mean gains of 5-24 points in post-test scores.

Jafarian and Kramer (2025) found that AI-assisted audio-learning improved academic achievement through increased motivation and reading engagement ($d \approx 0.40$). Luan et al. (2026) reported that AI integrated with multiple intelligences in project-based learning significantly enhanced English achievement. Yu Wan et al. (2025) identified impact pathways of AI-supported instruction on learning behaviors, competence development, and academic achievement in engineering education.

3. Synergistic Effects of AI-Based Gamification

Combined approaches yielded the most robust outcomes. Studies integrating AI personalization with gamified elements (points, adaptive challenges, leaderboards) reported superior gains in achievement,

motivation, and retention (Adi et al., 2026; Taisin et al., 2025; Information, 2026). Adi et al. (2026) concluded that AI's corrective role amplifies the motivational impact of game elements. Taisin et al. (2025) demonstrated that AI-supported gamification significantly improved learning performance by advancing intrinsic motivation.

4. Mechanisms and Moderators

Drawing on self-determination theory (Ryan & Deci, 2000), the reviewed studies consistently identify three psychological mechanisms: (1) real-time adaptive feedback (competence); (2) choice over learning paths (autonomy); and (3) social comparison and collaboration (relatedness).

Four critical moderators were identified: (1) subject domain (STEM > humanities); (2) group size (small > large); (3) baseline achievement (low-achieving students benefited most); and (4) intervention duration (peak at 8-12 weeks).

Table 1. Summary of Effect Sizes by Intervention Type

Intervention Type	Effect Size (Hedge's g)	Category
Gamification only	0.79 - 1.12	Moderate - Large

Intervention Type	Effect Size (Hedge's g)	Category
AI only	0.40 - 0.97	Moderate - Large
Combined AI + Gamification	up to 1.24	Very Large

Source: Adi et al. (2026); Kam & Umar (2023); Ren et al. (2024)

Table 2. Moderators of AI-Gamification Effectiveness

Moderator	Level	Effect Size (g)	Explanation
STEM domain	STEM	0.98	Stronger effects
Humanities domain	Humanities	0.62	Weaker effects
Small group	<100 students	1.12	Optimal
Large group	>100 students	0.51	Less effective
Optimal duration	8-12 weeks	1.18	Peak effectiveness
Long duration	>24 weeks	0.61	Novelty decay

5. Challenges and Limitations

Challenges noted across studies include technical barriers, potential over-competition, and equity issues in low-resource settings (Unleashing gamification, 2025; Rodriguez-

Segura, 2022). Digital divide concerns remain salient: without reliable device and internet access, AI-gamification platforms may widen existing achievement gaps (Major et al., 2021; Information, 2026).

Recent research has also highlighted ethical considerations, including data privacy, algorithmic bias, and the risk of over-reliance on extrinsic rewards (Adi et al., 2026; Tlili et al., 2021).

D. Conclusion

This systematic review of 124 studies (2021-2026) provides robust evidence that both AI-based learning and gamification independently improve academic achievement, and their integration produces the largest gains (effect sizes up to Hedge's $g = 1.24$). The mechanisms are well-established: AI enables adaptive, personalized scaffolding at scale, while gamification sustains engagement and intrinsic motivation through autonomy, competence, and relatedness support. Combined AI-gamification approaches are significantly more effective than either alone, particularly for lower-achieving students, in STEM subjects, and in small-to-medium group settings.

Practical implications: Teachers should integrate adaptive gamified quizzes; curriculum designers should prioritize STEM subjects for AI-gamification implementation; school administrators must ensure device and internet access before platform adoption; and policymakers should fund teacher training on AI tools and gamification pedagogy.

Limitations of this review: English-language articles only from Scopus, WoS, and ERIC; potential publication bias; high statistical heterogeneity; short intervention durations in most studies; and lack of developing country representation. Future research directions: Long-term retention effects, cross-cultural replication, generative AI integration, and cost-effectiveness of AI-gamification platforms. Integrating AI and gamification offers a scalable, evidence-based pathway to elevate academic achievement, but it is not a panacea. Without attention to digital equity, teacher training, and intrinsic motivation, these tools risk widening achievement gaps.

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