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PAPER

AI-Driven Adaptive Gamification of E-Learning in Higher Education: A Systematic Literature Review (2023–2026)

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ABSTRACT

University e-learning environments continue to struggle with disengagement and attrition, and gamification remains one of the most widely tested remedies. Since 2023, the diffusion of machine-learning personalization, learning analytics, and, above all, generative artificial intelligence (AI) such as large language models, GANs, and conversational and multimodal agents, has visibly reshaped how gamification is designed, implemented, and studied in higher education. This paper reports a PRISMA-2020-compliant systematic literature review of empirical and conceptual studies on AI-driven and AI-augmented gamification of e-learning in higher education, published between January 2023 and mid-2026. Searches of Scopus, Web of Science, and Google Scholar, supplemented by backward and forward snowballing, yielded 1,142 unique records after de-duplication; 68 studies met the inclusion criteria after a two-stage screening process (44 empirical studies, 24 conceptual/framework proposals). We find that (i) classic points-badges-leaderboards (PBL) elements persist but are now frequently AI-parameterized, alongside a marked rise in AI-personalized 'deeper' elements such as challenges and narrative; (ii) four converging technique families—supervised/unsupervised learner-profiling, reinforcement learning, learning-analytics dashboards, and generative content/feedback engines—dominate the corpus; (iii) theoretical grounding remains uneven, with self-determination theory the dominant but frequently under-specified framework and a distinct, largely unaddressed gap around the theoretical justification of the adaptation/generation layer itself; and (iv) a four-way classification—adaptive, generative, hybrid adaptive-generative, and immersive/multimodal—captures the current design space more precisely than a purely structural/content view of gamification. We close with a research agenda addressing content-level personalization, longitudinal validation, and the ethical governance of learner data in AI-gamified systems.

KEYWORDS

gamification, adaptive learning, artificial intelligence (AI), generative AI, large language models, higher education, e-learning, systematic literature review, personalization, learning analytics

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1 INTRODUCTION

Gamification—the use of game-design elements in non-game settings—has been a fixture of higher-education instructional design for over a decade, motivated by persistently high attrition and disengagement in online and blended courses. Its promise has always rested on a design problem that the field has never fully solved: which combination of game elements, for which learners, and in which content area actually sustains motivation rather than merely decorating a course shell? Over the last three years, two converging technological shifts have directly reopened that design problem. The first is the maturation of machine-learning-based learner modelling and learning analytics, which makes data-driven personalization of game elements operationally feasible at scale rather than a theoretical aspiration. The second, more disruptive shift is the arrival of generative artificial intelligence (AI)—large language models together with image- and video-generation models—which for the first time allows the gamified content itself (scenarios, quests, narrative, feedback, and even avatars) to be authored or re-authored automatically rather than merely wrapped around static instructional material.

Recent reviews describe this convergence as turning gamification from a fixed motivational overlay into a dynamic, data-driven ecosystem integrating behavioral modelling, adaptive algorithms, and intelligent feedback. Yet this literature is still young, fragmented across adjacent research communities (educational technology, human-computer interaction, learning analytics, and AI ethics), and unevenly focused: several reviews address AI and gamification in general or non-educational contexts, others address AI-supported personalized learning without a specific gamification focus, and few restrict their scope tightly to higher-education e-learning across the full 2023–2026 window during which generative AI became mainstream. A dedicated, PRISMA-based synthesis of this specific intersection is therefore both timely and, to our knowledge, still missing.

Accordingly, this review pursues four research questions:

RQ1 – Which game elements are used in AI-driven gamified e-learning systems in higher education, and how are they combined?
RQ2 – Which AI techniques (machine learning, learning analytics, generative AI) are employed, and for what design function (profiling, adaptation, content generation, feedback)?
RQ3 – To what extent is the design of AI-driven gamified systems grounded in motivational or learning theory?
RQ4 – How can the resulting design space be classified?

The remainder of the paper is organized as follows: Section 2 reviews prior surveys relevant to this topic. Section 3 details the PRISMA-based systematic review methodology. Section 4 reports results for each research question. Section 5 discusses cross-cutting trends, persistent gaps, and design guidelines. Section 6 concludes with a future research agenda.

2 PRIOR REVIEWS

Gamification of higher-education e-learning has been the subject of several systematic reviews over the past decade, most of which predate the generative-AI era

and therefore treat game elements, theoretical grounding, and design approaches as largely static properties of a system rather than as targets of algorithmic personalization. One frequently cited review in this line, covering the pre-2022 literature, found that classic points-badges-leaderboard elements dominated practice, that only a minority of empirical studies invoked any motivational theory, and that gamification approaches proposed for higher education were almost entirely structural—game mechanics wrapped around unchanged instructional content—with content-level and genuinely personalized gamification remaining marginal [1].

Since 2023, a distinct cluster of reviews has begun to document the specific convergence of AI and gamification. Kassenkhan et al. [2], in a systematic review published in Information, frame AI-supported gamification as an information-centered ecosystem integrating learning analytics, behavioral modeling, and adaptive algorithms, documenting a sharp acceleration in publication output from 2024 onward, though their scope spans all educational levels rather than higher education specifically. A large-scale bibliometric and thematic review by Bulut and Ulusoy [3], covering 884 publications on AI and gamification generally between 2004 and 2025, identifies five thematic clusters—AI-driven personalization in education, serious-game design, human-machine interaction, algorithmic data analytics, and ethical concerns—but is not restricted to e-learning or to higher education. Adi et al. [4], in an integrative review in the Journal of Computers in Education, frame AI as a corrective mechanism for well-documented weaknesses of conventional gamification, such as reward dependency and superficial engagement, while Niyazova et al. [5], in a parallel review and meta-analysis in Frontiers in Education, target school (K-12) rather than tertiary education specifically.

Closer to the present scope, Suresh Babu and Dhakshina Moorthy [6] reviewed 29 studies (from an initial pool of 622) specifically on AI applications in adaptive educational gamification, mapping gamification elements, user-profile variables, and intelligent techniques, though their review was not restricted to higher education and closed its search before the subsequent wave of generative-AI-enabled content gamification. Velázquez-García et al. [7] catalogue the mechanisms by which AI can support educational gamification—adaptive content delivery, intelligent tutoring, content generation, automated assessment, and automated management—in the specific context of higher education, but as a conceptual discussion rather than a systematic synthesis of empirical evidence. Abbes et al. [8], in a review in SN Computer Science on generative AI and gamification for personalized learning, explicitly call for a 'dynamic adaptation engine' combining generative and adaptive gamification, a hybridization question this review addresses directly under RQ4.

Across this literature, ethical and data-governance dimensions—privacy, algorithmic bias, transparency of adaptive decisions—recur as a distinct concern in several 2025–2026 reviews of AI in education generally [9], [10], without yet being consistently integrated into gamification-specific design frameworks. Taken together, prior reviews establish that AI-gamification convergence is a fast-growing but still fragmented area and motivate a synthesis scoped specifically to higher-education e-learning across the 2023–2026 period, which the present review provides.

3 SYSTEMATIC LITERATURE REVIEW METHODOLOGY

3.1 Review protocol and research questions

This review follows the PRISMA 2020 statement for reporting systematic reviews, structured in three phases—planning, conducting, and reporting—and organized around the four research questions stated in Section 1.

3.2 Search strategy

Search strings combined three concept blocks using Boolean operators: (a) gamification terms (gamif*, gameful, "game element*", "game mechanic*", "game dynamic*"); (b) AI terms ("artificial intelligence," "machine learning," "deep learning," "generative AI," "large language model*", "adaptive learning," "learning analytics," "chatbot*"); and (c) context terms ("higher education," "university*", "undergraduate*", "e-learning," "online learning," "MOOC*"). Searches were run in Scopus, Web of Science, and Google Scholar and restricted to records published between 1 January 2023 and 30 June 2026. Backward and forward snowballing on the reference and citation lists of all included studies supplemented the database search.

3.3 Inclusion and exclusion criteria

Included: peer-reviewed journal articles, conference papers, and rigorous preprints (2023–2026); studies addressing gamification as the application of game-design elements in non-game contexts, explicitly combined with an AI/ML/analytics/generative component; higher-education or university-level e-learning context; English-language full text available.

Excluded: game-based learning, serious games or full video games without a gamification of existing activity framing, K-12 or purely corporate-training contexts, studies mentioning AI or gamification only tangentially without empirical or design detail, and duplicate conference-to-journal pairs (journal version retained).

3.4 Study selection and data extraction

Two reviewers independently screened titles and abstracts, then full texts, with disagreements resolved by discussion and, where necessary, a third reviewer. A structured extraction form was captured for each included study, publication year, and venue, educational context, gamification elements, AI technique(s), design function of the AI component, theoretical framework (if any), study design, and, where available, outcome measures. Figure 1 summarizes the selection process following the PRISMA 2020 flow diagram.

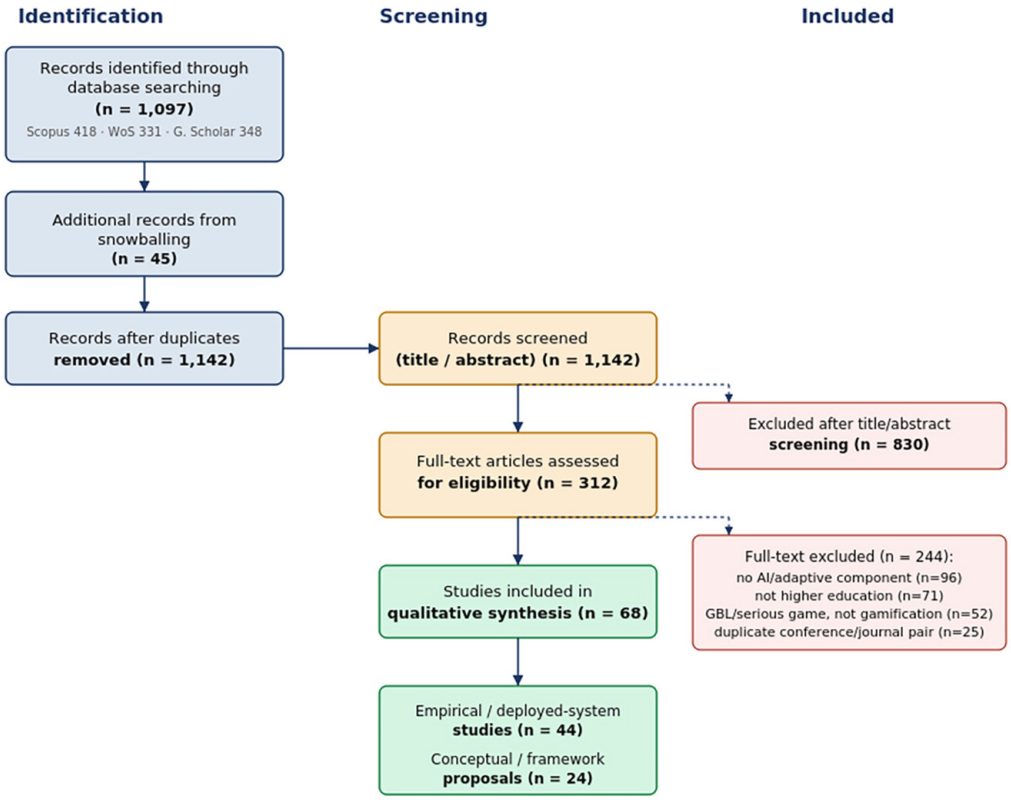


Fig. 1. PRISMA 2020 flow diagram of the study selection process

Database searching identified 1,097 records (Scopus n = 418; Web of Science n = 331; Google Scholar n = 348), supplemented by 45 additional records from snowballing, for 1,142 unique records after deduplication. Title/abstract screening excluded 830 records as clearly out of scope, leaving 312 full-text articles assessed for eligibility. Full-text review excluded a further 244 records—96 for lacking any AI or adaptive component, 71 for not addressing higher education, 52 for being game-based learning or serious-game studies rather than gamification of an existing activity, and 25 as duplicate conference/journal pairs—leaving 68 studies in the final corpus (44 empirical studies with a deployed or piloted system and 24 conceptual/framework proposals).

4 RESULTS

4.1 Publication trends

The yearly count of eligible studies in the corpus rises from single digits in 2023 to a clear majority concentrated in 2025 and the first half of 2026, mirroring the diffusion curve of generative AI tools into educational research more broadly and indicating that AI-driven gamification has moved from an emerging niche to an active mainstream research line within the review period.

4.2 RQ1 – Game elements and their combination

Points, badges, and leaderboards remain the single most frequent element family in the corpus, but they are now more often reported as AI-parameterized

(e.g., badge thresholds or leaderboard cohorts recomputed from a learner model) rather than fixed and identical for all learners. Levels and feedback likewise persist as core elements, and feedback in particular has shifted qualitatively: several studies report AI-generated, individualized formative feedback text delivered through the gamified interface rather than templated feedback messages, with adaptive scaffolding identified as the dominant pedagogical function of this AI-driven feedback. 'Deeper' elements such as challenges, storytelling/narrative, and avatars are common in the corpus and are frequently the object of AI personalization or generation themselves—for example, narrative branches or challenge sequences produced or adjusted by a generative model rather than authored once and reused identically for every learner. Combinations of three or more elements, often spanning both PBL and deeper categories, are typical; studies rarely justify the specific combination chosen beyond referencing general engagement goals.

4.3 RQ2 – AI techniques and their design function

Four technique families recur across the corpus, often in combination: (1) learner profiling and clustering (supervised/unsupervised ML), used to segment learners by player type, learning style, or engagement pattern and to select or weight game elements accordingly; (2) adaptive-difficulty and reinforcement-learning engines, used to adjust challenge level, pacing, or reward schedule in near-real time based on performance and behavioral signals; (3) learning-analytics dashboards, used less to change the gamified experience directly than to make engagement and risk visible to instructors and, in some designs, to learners themselves; and (4) generative AI (large language models and, less frequently, image/video generation), used to author quiz items, narrative scenarios, individualized feedback text, conversational non-player characters, and, in immersive designs, dynamic VR/AR dialogue and content.

A growing share of studies combine at least two of these families—typically a profiling/adaptation engine feeding a generative content or feedback module—which motivates the hybrid category introduced under RQ4.

4.4 RQ3 – Theoretical grounding

Explicit theoretical grounding remains uneven across the corpus. Self-determination theory is the single most cited framework, consistent with earlier reviews of gamification generally, followed at some distance by flow theory and goal-setting theory; a substantial share of studies, however, report no explicit theoretical framework at all. A recurring pattern in the AI-specific literature is that theoretical justification, where present, is offered for the choice of game elements but rarely extended to the AI/adaptation layer itself: studies explain why a badge or challenge should motivate learners under SDT but rarely articulate a theoretical account of how algorithmic personalization should be calibrated, leaving the adaptation logic empirically or heuristically driven rather than theory-driven. Ethical and data-governance considerations—privacy, algorithmic bias, and transparency of adaptive decisions—are flagged as a distinct and growing concern across multiple 2025–2026 reviews of AI in education but are seldom integrated into the same design frameworks that specify game elements and AI techniques in the studies reviewed here [9], [10].

4.5 RQ4 – A classification of AI-driven gamification approaches

The design space identified in this review is organized around the locus and function of the AI component into four categories, summarized in Table 1: adaptive, generative, hybrid adaptive-generative, and immersive/multimodal. Adaptive approaches use machine-learning back-ends to re-parameterize existing game elements per learner. Generative approaches use generative AI to produce or re-author the gamified content itself—narrative, scenarios, feedback—addressing the content-gamification gap noted in prior reviews of the pre-AI literature. Hybrid adaptive-generative approaches, still a minority but growing quickly toward 2026, combine both functions and are explicitly called for by Abbes et al. [8] as the field's logical next step. Immersive/multimodal approaches extend gamification into VR/AR and conversational-agent environments where AI governs not only what content appears but how it is delivered.

Table 1. Proposed classification of AI-driven gamification approaches in higher-education e-learning, 2023–2026

Category	Defining Logic	Typical AI/Technique	Illustrative Sources
Adaptive gamification	Game elements (points, badges, challenges, difficulty) are dynamically re-parameterized per learner profile or behavior trace.	Supervised/unsupervised ML, clustering of player types, reinforcement learning, learning-analytics dashboards.	[11], [6], [3]
Generative gamification	Game content itself (scenarios, quests, quiz items, narrative, and feedback text) is authored or re-authored by a generative model.	Large language models, GANs, diffusion models for narrative/asset generation.	[8], [7]
Hybrid adaptive-generative	An adaptation engine decides what to change, a generative component produces the corresponding content or feedback in real time.	ML-driven learner model coupled to an LLM content/ feedback generator.	[12], [13]
Immersive/ multimodal gamification	The gamified experience is embedded in VR/AR or conversational agents with non-scripted, AI-driven dialogue and world state.	Conversational AI, generative VR environments, biosignal-driven companions.	[14]

5 DISCUSSION

5.1 Cross-cutting trends

Three trends cut across the corpus. First, personalization has moved from a conceptual aspiration to an operational default in a substantial share of recent systems, implemented through learner-profiling and adaptive-difficulty techniques rather than static branching rules. Second, content-level gamification—narrative, scenario, and feedback generation—is now directly enabled by generative AI, addressing a design gap that earlier, pre-AI reviews of the field consistently identified as under-explored. Third, publication volume in this specific intersection has grown sharply and continues to accelerate through 2026, consistent with the broader diffusion of generative AI into higher-education research documented in bibliometric studies of GenAI in education [15].

5.2 Persistent gaps

Despite this progress, two gaps persist. The first is a theory gap specific to the AI layer: while motivational theory is increasingly invoked to justify game-element choice, it is rarely extended to justify how adaptation or generation parameters should be calibrated, tuned, or bounded, leaving that layer largely atheoretical. The second is an evidence gap: a majority of conceptual/framework proposals in the corpus lack a controlled empirical evaluation, and among empirical studies, most report short, single-course, single-semester deployments rather than longitudinal or multi-institution evidence. Ethical and data-governance concerns—privacy, bias, explainability of adaptive decisions—are consistently flagged across the wider AI-in-education literature [9], [10] but rarely integrated into the gamification-specific design frameworks reviewed here.

5.3 Design guidelines

- Treat the adaptation/generation layer as a first-class design object with its own theoretical justification, not merely an implementation detail bolted onto a theory-grounded choice of game elements.
- Prioritize content-level generative interventions (narrative, scenario, feedback) where they can be pedagogically validated, since this is where AI most directly addresses the structural/content gap noted in earlier reviews.
- Build data-governance and explainability requirements into the design process from the outset, rather than addressing them post hoc.
- Report empirical validation with explicit comparison groups and, where feasible, longitudinal follow-up, to address the persistent evidence gap identified in this review.

6 CONCLUSION AND FUTURE RESEARCH AGENDA

This systematic review maps how artificial intelligence—machine-learning personalization, learning analytics, and generative AI—has reshaped the design of gamified e-learning in higher education between 2023 and mid-2026. Following a PRISMA 2020 protocol, 68 studies were retained from 1,142 unique records. We find real progress toward addressing two long-standing weaknesses of gamification design—weak theoretical grounding and near-absence of content gamification—alongside the emergence of a new design category, generative gamification that did not exist as an operational possibility before the arrival of large language models. A four-way classification (adaptive, generative, hybrid adaptive-generative, immersive/multimodal) is proposed to capture this expanded design space.

Future research should prioritize (a) hybrid adaptive-generative architectures that couple learner modelling with generative content and feedback, explicitly called for but rarely implemented in the current corpus; (b) theory-driven specifications for how adaptation parameters should be calibrated, extending motivational theory beyond element choice into the algorithmic layer; (c) longitudinal, multi-institution empirical validation, addressing the persistent evidence gap identified in Section 5; and (d) design frameworks that integrate data privacy, bias mitigation and explainability requirements alongside motivational and game-design considerations, rather

than treating them as separate ethical add-ons. Given the acceleration in publication volume documented here and in concurrent reviews, we recommend that the field commit to periodic, PRISMA-based updates of this kind of synthesis at roughly two-year intervals.

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