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Review Article

Harnessing Gamification for Medical Education: A Synthesis of Its Educational Applications

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Abstract

Background: Despite the exponential adoption of game-based instructional mechanics in healthcare training, empirical evidence remains conceptually fragmented and heavily skewed toward descriptive, single-institution interventions.

Objectives: This study systematically synthesizes qualitative and mixed-method evidence (2000–2025) to establish a conceptually rigorous, practice-oriented taxonomy and quantify the relative curricular prominence of gamification applications in medical education.

Methods: A knowledge-integration meta-synthesis was conducted following Sandelowski and Barroso's framework and PRISMA guidelines across six major databases: Medline (PubMed), Embase, CINAHL, Web of Science, Scopus, and Google Scholar (search cutoff: March 2025). Methodological quality was appraised using an adapted 10-item Critical Appraisal Skills Programme (CASP) checklist (inclusion threshold ≥50%). Themes were extracted via inductive constant comparison and weighted using objective Shannon entropy analysis (W).

Results: Thirty-nine eligible studies were synthesized, yielding five core dimensions: Curricula (W=0.491), Teaching-Learning Processes (W=0.227), Faculty Engagement (W=0.201), Assessment (W=0.152), and Student Competencies (W=0.054). While student-level engagement dominated nominal study volume, curricular integration and institutional sustainability carried the highest information weight and complexity.

Conclusion: Gamification is not an off-the-shelf instructional remedy. Effective adoption requires a "glocalized" implementation model that balances intrinsic motivational mechanics against faculty pedagogical workload, institutional infrastructure, and formal curricular alignment.

Keywords: Gamification; Medical Education; Curriculum Design; Educational Measurement; Faculty Development; Meta-Synthesis; Shannon Entropy; Self-Determination Theory

Background

Artificial intelligence has significantly impacted various fields, including science, business, and education (1). Education is continually evolving, with new learning modalities being developed (2). Among these, game-based learning has emerged as a key driver of digital transformation in education (3). The term "gamification" was introduced in the early 2000s and gained substantial recognition by the late 2010s; Gartner predicted in 2015 that 40% of top companies would adopt it for customer engagement (4). In education, gamification is increasingly important in medical training, particularly as Generation Z enters medical education (5). The increasing relevance of gamification stems from fundamental pedagogical shifts. The traditional teacher-centered model, in which knowledge

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is passively transmitted, is increasingly viewed as inadequate for contemporary learners (6). Modern students, having matured in a digital ecosystem, often find non-interactive methods unengaging. Consequently, medical education has increasingly incorporated technologies such as computer-assisted learning and simulation-based training (7). These digital innovations are particularly valuable for bridging the gap between theoretical knowledge and real-world clinical application (8).

Among these innovations, gamification stands out for its capacity to overcome the limitations of conventional education and accelerate pedagogical transformation (9). Empirical studies indicate that game elements can enhance intrinsic motivation, stimulate active participation, and facilitate understanding of complex topics (10, 11). Notably, gamification has been shown to improve both motivation and academic performance among nursing and medical students (12). Nevertheless, several formidable barriers impede the widespread adoption of gamification. The development and maintenance of educational games are costly, and gamified content often suffers from a limited effective lifespan (13). Assessing learner performance, especially practical skills, remains challenging (14). Ethical concerns,
such as cheating and manipulation of the reward system, must be considered, in addition to safety and legal issues (15, 16). Furthermore, infrastructural inadequacies often hinder implementation (17).

Although gamification is gaining popularity, current research and case studies on the topic have largely been descriptive and have not followed the systematic procedures needed to identify conceptual constructs and critical categories. To address this gap, the current study used meta-synthesis a qualitative research method that involves not only synthesizing findings but also integrating concepts and themes from multiple sources. Meta-synthesis differs from quantitative meta-analysis in that its goal is conceptual integration rather than empirical generalization. Accordingly, this review aims to provide a theoretically grounded and practice-oriented understanding of gamification.

Objectives

The central research question is: “What are the most important educational applications and functions of gamification in medical education?”

Methods

Our review adopted a knowledge-integration approach based on meta-synthesis methodology. Because the aim was not merely to summarize the available evidence but also to integrate conceptual elements from multiple studies and develop a more comprehensive understanding of the phenomenon (18), meta-synthesis was considered an appropriate approach. The synthesis was intended not only to integrate study findings but also to contribute to the development of new theoretical insights and practical applications. Although both meta-analysis and meta-synthesis involve the integration of findings from multiple studies, they differ in their methodological approaches. Meta-analysis is a quantitative method that statistically combines empirical data to estimate overall or generalizable effects, whereas meta-synthesis is a qualitative method that focuses on theories and themes derived primarily from qualitative research studies (19). As this study involved the synthesis of previously published, publicly accessible literature and did not involve human subjects or primary data collection, formal ethical approval was not required.

Search Strategy: To address the primary research question regarding the most important uses of gamification in medical education, we conducted a systematic search across Medline (PubMed), Embase, CINAHL, Web of Science, Scopus, and Google Scholar, with the last update performed in March 2025.The search strategy, developed in collaboration with a health sciences librarian, combined MeSH terms, free-text keywords, and synonyms for "gamification" to ensure both comprehensiveness and precision. The 2000–2025 timeframe was selected based on the initial formal introduction of this term in academic literature; notably, publications released after March 2025 were not included.

In Medline (PubMed), MeSH headings including Gamification, Education (Medical), and Serious Games were utilized alongside keywords such as game-based learning and educational games combined with medicine and health education. A broader search in Embase employed controlled vocabulary (gamification, medical education, simulation training) and terms like "serious games," "digital games,", and "simulation learning." For CINAHL, terms including "gamification," "engagement strategies," "interactive learning,", and “simulation training “were mapped to the headings Gamification and Educational Technology. Web of Science provided interdisciplinary coverage using queries such as ("gamification" AND "medical education") or ("serious games" AND "healthcare training"). In Scopus, the search was restricted to Medicine and Technology subject areas, incorporating game-based learning, virtual simulation, and game

elements alongside medical students and health education. Finally, to capture grey literature, recent open-access studies, and articles not yet indexed elsewhere, a supplementary Google Scholar search was performed using simple phrases (gamification in medical education, serious games in healthcare, gameful design AND curriculum), restricted to the first 200 records to minimize the inclusion of non-peer-reviewed or irrelevant content.

Inclusion and Exclusion Criteria: To ensure analytical rigor, prespecified eligibility criteria were applied. Eligible publications were peer-reviewed empirical studies, systematic reviews, and meta-analyses that examined gamification and its effects in medical education. Reviews and meta-analyses were included to provide broader conceptual and contextual insights that could not be obtained from empirical studies alone. Only articles that had been published between the years 2000 and 2025 were taken into consideration, and articles that were not in the English language were ignored. The restriction to English-language publications was made to support consistent and accurate synthesis; however, it may have introduced language bias and resulted in the exclusion of relevant studies. Studies that did not meet the prespecified methodological-quality threshold were excluded from the synthesis. A key methodological challenge was the potential double-counting of primary studies when two or more included reviews contained overlapping evidence. To avoid this, we implemented the following procedures: (a) when any review cited an original primary study, we cross-verified that study in our own records of full texts; (b) before synthesizing the evidence, we identified primary studies that appeared in multiple reviews and counted each primary study only once; and (c) the focus of the selected reviews was on their conclusions rather than their data.

Search Outcomes: A screening protocol was developed by two research team members, following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Figure 1). The screening procedure consisted of three stages. In the first stage, an extensive review of titles and abstracts was conducted to identify and exclude duplicate studies. After removing duplicates, the eligibility criteria were applied to the remaining studies. In the second phase, an independent evaluation of the articles was carried out by the other two team members who were to reject the articles that did not contribute towards the objective of the study. This dual-review process improved the relevance and reliability of the findings. In the third phase, the four reviewers collaboratively finalized the screening decisions and synthesized the screening outcomes, which was supervised by another researcher to assure the quality of the process. The inter-rater reliability for a randomly selected 20% of titles and abstracts (Cohen's $\kappa = 0.83$) and full-text articles ($\kappa = 0.79$) indicated a high level of agreement among reviewers. The description of the screening process is presented in the diagram shown in Figure 1.

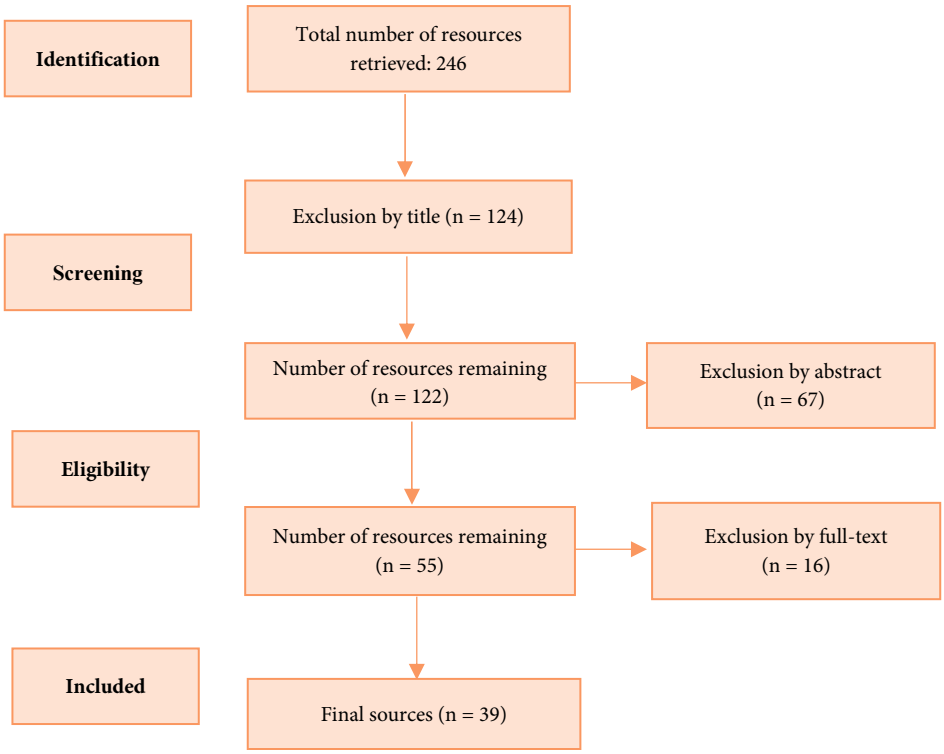


Figure 1. PRISMA Flow Diagram of Study Selection Process

Quality Appraisal: To ensure methodological rigor, all included studies were critically appraised using the Critical Appraisal Skills Programme (CASP) qualitative checklist, a widely used and validated tool in medical education research. Although the CASP checklist was originally developed for primary qualitative research, its application to systematic and narrative reviews was justified by two considerations: (a) the included reviews synthesized qualitative, conceptual, and experiential evidence; and (b) the adapted checklist focused on essential methodological quality criteria. The adaptation considered the clarity of research aims, appropriateness of methodology, transparency of data collection and analysis, and applicability of findings. The same criteria were applied to both primary qualitative studies and secondary reviews because all included studies were qualitative in nature. Although the CASP guidelines do not provide formal recommendations for quantitative scoring, a numerical scoring approach was used to enhance transparency and comparability. For transparency, responses were scored as follows: Yes = 10, Can't Tell = 5, and No = 0, yielding a total score ranging from 0 to 100.

This scoring approach has been validated and applied in similar meta-analyses in health professions education. A 50-point threshold was established a priori: studies scoring below 50 met fewer than half of the assessed CASP criteria with a "Yes" response, indicating substantial methodological limitations that could compromise the interpretative validity of the synthesis. Studies scoring below 50 were excluded from the final synthesis but retained for audit purposes. Four reviewers (AK, FG, YA, and MS) independently appraised the methodological quality of the included studies. Any discrepancies in quality ratings were resolved through consensus discussions; when consensus could not be reached, an independent external reviewer was consulted Inter-rater reliability for the CASP scores was 0.81, indicating good agreement among reviewers. The quality appraisal results and CASP scores for each study are presented in Table 1.

Table 1. Quality assessment of selected articles based on the CASP

Reference	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Total
(20)	Y	Y	CT	Y	Y	N	N	Y	Y	Y	75
(21)	Y	Y	CT	N	Y	N	N	Y	Y	Y	75
(22)	Y	Y	Y	N	Y	N	N	Y	Y	CT	65
(23)	Y	Y	Y	CT	N	N	Y	Y	Y	Y	75
(24)	Y	CT	CT	N	N	N	Y	Y	Y	Y	60
(25)	Y	N	Y	Y	Y	N	Y	Y	Y	Y	80
(26)	Y	Y	Y	Y	CT	N	Y	Y	Y	Y	95
(27)	Y	Y	CT	CT	N	N	CT	CT	Y	Y	60
(28)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	100
(29)	Y	N	CT	N	Y	N	CT	CT	CT	Y	50
(30)	Y	Y	Y	CT	Y	N	Y	Y	Y	Y	85
(31)	Y	Y	Y	CT	Y	N	CT	CT	Y	Y	75
(32)	Y	Y	Y	N	N	N	Y	Y	Y	Y	70
(33)	Y	Y	Y	N	Y	N	Y	Y	Y	Y	80
(34)	Y	Y	Y	N	N	N	Y	Y	Y	Y	70
(35)	Y	Y	Y	CT	N	N	Y	Y	Y	Y	75
(36)	Y	Y	Y	Y	N	N	Y	Y	Y	Y	80
(37)	Y	Y	CT	CT	N	N	CT	CT	Y	Y	60
(38)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	100
(39)	Y	Y	Y	CT	N	N	Y	N	Y	Y	75
(40)	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	100
(41)	Y	Y	Y	Y	N	N	Y	Y	Y	Y	80
(42)	Y	CT	CT	CT	CT	N	CT	CT	Y	Y	60
(43)	Y	Y	Y	Y	N	N	Y	Y	Y	Y	80
(44)	Y	Y	Y	Y	N	N	Y	Y	Y	Y	80
(45)	Y	Y	CT	Y	N	N	CT	CT	Y	Y	65
(46)	Y	Y	CT	Y	N	N	CT	CT	Y	Y	65
(47)	Y	CT	CT	CT	N	N	CT	CT	Y	Y	55
(48)	Y	Y	Y	N	N	N	CT	Y	Y	Y	65
(49)	Y	Y	Y	Y	N	N	Y	Y	Y	Y	80
(50)	Y	Y	Y	CT	N	N	CT	Y	Y	Y	70

Reference	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Total
(51)	Y	Y	CT	CT	CT	N	Y	CT	CT	Y	65
(52)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	100
(53)	Y	Y	Y	Y	N	N	Y	Y	Y	Y	80
(54)	Y	CT	CT	CT	N	N	CT	CT	Y	Y	55
(55)	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	100
(56)	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	70
(57)	Y	Y	Y	Y	N	N	Y	Y	Y	Y	80
(58)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	100

Point 1: Y = Yes (10 points); CT = Can't Tell (5 points); N = No (0 points)

Point 2: Legend for Table 2 (CASP Criteria): Q1 – Clear statement of research aims; Q2 – Appropriate qualitative methodology; Q3 – Appropriate research design; Q4 – Appropriate recruitment strategy; Q5 – Data collected appropriately; Q6 – Researcher–participant relationship adequately considered; Q7 – Ethical issues taken into consideration; Q8 – Sufficiently rigorous data analysis; Q9 – Clear statement of findings; Q10 – Valuable research

Note: *Quality appraisal of the thirty-nine included studies assessed via the ten Critical Appraisal Skills Programme (CASP) criteria (scored 0–100; a-priori exclusion threshold set at 50 points). Y = Yes (10 points); CT = Can't Tell (5 points); N = No (0 points).*

Figure 2 illustrates the percentage distribution of included studies across CASP-score quartiles.

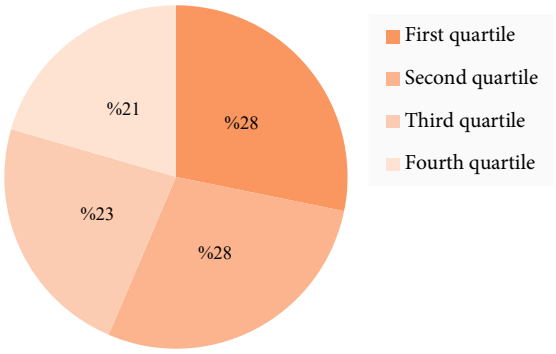


Figure 2. Percentage distribution of included studies across quartiles based on CASP scores above 50

Data Abstraction: Two members of the research team independently extracted key information from each included article, including the authors' names, year of publication, country of origin, study design, and main findings. The remaining team members then independently conducted a thematic analysis of the extracted data. Finally, the study findings were categorized through an iterative process of comparison and synthesis. Microsoft Word was selected for data management for several reasons. Although qualitative data-analysis software provides advanced features, Microsoft Word was used to maintain a transparent, linear, and easily shareable audit trail among the research team members. The processes of data classification and summarization were documented in Microsoft Word and subsequently presented in Table 2.

Data Synthesis: Qualitative findings were synthesized using the inductive meta-synthesis approach of Sandelowski and Barroso (18) to generate novel theoretical insights through systematic interpretation. The first step involved open coding to identify initial concepts and patterns within the primary findings. Methodological and theoretical memos were documented throughout this stage to capture emerging insights and conceptual linkages among codes. Subsequently, initial codes were grouped into subthemes to construct overarching conceptual categories. Each category was refined through constant comparative analysis to ensure conceptual clarity and internal coherence. Finally, these categories were integrated into an overarching qualitative synthesis that offers a comprehensive conceptualization of the phenomenon under study.

Data Validation: To enhance analytical rigor and trustworthiness, investigator triangulation was employed. All reviewers independently coded and interpreted the findings before convening consensus meetings to reconcile discrepancies and agree on final interpretations. This iterative process enhanced the credibility, confirmability, and dependability of the synthesized findings. If consensus could not be reached after two rounds of discussion, an external qualitative researcher was consulted to adjudicate disagreements.

In line with established qualitative standards, the preliminary findings underwent peer debriefing to broaden interpretive perspectives and enhance study credibility. Specifically, initial codes, candidate themes, and the overarching framework were reviewed by independent experts to minimize individual researcher bias. This process mitigated individual subjectivity and reflexivity blind spots. As Burnard et al. (59) noted, peer debriefing fosters conceptual refinement through critical dialogue and collaborative reflection. Consequently, this technique maintained qualitative interpretative flexibility while bolstering the validity and auditability of the final synthesis.

Table 2. Summary of key characteristics of selected studies

Reference	Author(s)	Year	Country	Study Design	Key findings
(20)	McCoy et al.	2016	USA	Narrative Review	Gamified learning systems improve medical education through increasing learner engagement, aiding clinical decision-making, and adopting interactive technology-based learning techniques.
(21)	Krishnamurthy et al.	2022	USA, Malaysia, Singapore	Systematic Review	Educational games, mobile applications, and virtual patient simulation programs increase learner engagement, decision making, and real-world clinical applications in both preclinical and clinical teaching.
(22)	van Gaalen et al.	2021	Netherlands	Systematic Review	Gamification has the potential to facilitate better learning results in health profession education, specifically when combined with assessment and challenge components, but research usually lacks theory and adequate control groups.
(23)	Fathi Najafi et al.	2024	Iran	Systematic Review	Gamified learning has been found to enhance the knowledge and practical skills of midwifery students, being more effective than conventional educational techniques in clinical settings.
(24)	Lee et al.	2023	Multinational	Scoping Review	Gamification is an efficient technique for clinical reasoning teaching, but its theoretical framework, especially with regard to cognitive reasoning models, is scarce and inconsistent.
(25)	Oliver et al.	2024	United Kingdom	Qualitative	Motivation of students and good session design were identified as key aspects for successful implementation of gamification in IPL. Limitations consisted in weighting of credits, online sessions, and scheduling issues.
(26)	Luokkamäki et al.	2023	Finland	Qualitative	The 3D game Imagine enhanced nurses' medication administration competency, promoted self-reflection, and even influenced their clinical behavior. The game was especially useful for nursing students, recent graduates, and in continuing education, and is recommended for broader implementation in healthcare training programs.
(27)	White et al.	2018	USA	Conceptual	Gaming science offers a promising approach to integrate health systems science into medical education by enhancing strategic thinking and decision-making in complex clinical environments.
(28)	Ohn and Ohn	2023	Malaysia	Qualitative	Despite some user experience limitations, gamified learning significantly enhanced medical students' motivation and engagement in ECG education, highlighting the need for outcome-driven design refinement.
(29)	Lee et al.	2024	Taiwan	Scoping Review	Gamification is positioned as a promising pedagogical strategy to enhance clinical reasoning through increased learner engagement and knowledge retention, warranting systematic exploration of its implementation and outcomes.
(30)	Salehi et al.	2023	Iran	Systematic Review	90% of the reviewed studies reported positive impacts of gamification on medical students' learning, mapped across the Kirkpatrick model's four levels. The cognitive approach was the most dominant pedagogical method, while psychomotor learning was more frequent in electronic games and affective learning in non-electronic games.
(31)	Rahimi et al.	2023	Iran	Systematic Review	90% of the students were satisfied with gamification, considering it more efficient than conventional techniques and preferring its implementation at universities. 87% believed that gamified teaching contributed to their education better than any other technique, mostly through increasing their engagement, motivation, and collaboration.
(32)	Tung et al.	2023	USA	Systematic Review	Gamified learning demonstrates promising prospects in improving orthopedic surgery training via engagement and skill acquisition, although it is not implemented widely and the future development must focus on immersive, feedback-intensive simulation training.

Reference	Author(s)	Year	Country	Study Design	Key findings
(33)	Szeto et al.	2023	USA	Narrative Review	Gamified learning improves engagement, motivation, and results of education in medical studies, whereas there are already some preliminary findings about such benefits of gamification in dermatology education and patient outreach despite a small number of studies.
(34)	Zhao et al.	2020	China	Systematic Review	Digital games improve the acquisition and long-term retention of knowledge in medical studies better than conventional techniques, and students also prefer using games.
(35)	Nowbuth et al.	2020	Multinational	Systematic Review	Gamification is seen to have significant potential in improving antimicrobial stewardship and knowledge retention amongst future prescribers, however, studies conducted thus far are limited to the human health domain alone and fail to provide an evaluation framework.
(36)	Xu et al.	2023	China	Narrative Review	Game-based learning, which includes serious games and gamification, increases the effectiveness of medical education through the use of feedback, autonomy, and participation.
(37)	Tolks et al.	2022	Germany	Scoping Review	While the evidence is still scarce, the implementation of AI and game-based learning in healthcare, particularly in motor and cognitive rehabilitation, promises usability and motivational advantages, which should be explored in future studies on adaptive and interactive systems.
(38)	Wang et al.	2023	Taiwan	Qualitative	Thirteen major elements, specifically goal alignment, game rules, feedback, fairness, and scoring, were identified as necessary for the successful application of gamification in medical education, stressing the importance of incorporating principles of gamification purposefully in course curriculum design.
(39)	Shawaqfeh	2015	USA	Systematic Review	Gamification in pharmacy and healthcare education enhances student engagement, preparedness, and confidence in real-life scenarios, even if perceived academic performance remains unaffected.
(40)	Van Gaalen et al	2021	Netherlands	Qualitative	Students perceive pleasure as the main motivation for play, but see play and learning as potentially conflicting, requiring thoughtful integration of GBL. GBL should be optional, used for tedious or challenging topics, and its efficiency justified by learning gains—not just engagement.
(41)	Malicki et al.	2020	USA	Systematic Review	Interactive and gamification approaches improve engagement and satisfaction of adult nurses' learning experiences, even though no study has quantified their influence on knowledge retention and the issue requires additional attention.
(42)	Singhal et al.	2023	UK	Narrative Review	A properly designed gamification approach increases the effectiveness and engagement of medical education; however, success relies upon avoiding design mistakes and combining game components with the educational purpose.
(43)	Bigdeli and Kaufman	2017	Iran & Canada	Conceptual Review	There is a lack of theoretical clarity in the literature on game-based education in medical education; therefore, there is a necessity for developing standard definitions and classifications of the phenomenon.
(44)	Bigdeli and Kaufman	2017	Iran & Canada	Narrative review	It is crucial to identify the benefits, limitations, and engagement factors of digital educational games for effective implementation of game-based learning in health professionals' education.
(45)	Dereli and Kahraman	2023	Turkey & UK	Narrative Review	Gamification strategies such as escape rooms, board games, and case studies in virtual environment promote active and learner-centered learning in physiotherapy education.
(46)	Ahmadi et al.	2016	Iran	Critical Review	Gamification is a new educational technique in medical education that promotes behavioral engagement and integration of the learning process into general institutional strategy by means of motivational and interactive environment.

Reference	Author(s)	Year	Country	Study Design	Key findings
(47)	Chung et al.	2023	Hong Kong	Comprehensi Review	Game-based learning improves psychomotor skills, motivation, and engagement in orthopedic education through immersible techniques such as Virtual Reality/Augmented Reality and gamified assessment
(48)	Chytas et al.	2023	Greece	Systematic Review	Game-based learning in anatomy education generally improves academic performance, though evidence on its motivational advantage over traditional methods and the role of competitive intensity remains inconclusive.
(49)	Ijaz, et al.	2018	Pakistan, China	Systematic Review	Serious games show potential as complementary tools in healthcare professional training, but current evidence is limited and inconclusive due to heterogeneous methodologies and lack of standardized outcome measures.
(50)	Abdulmajed, et al.	2014	KSA, USA	Systematic Review	Although educational games have a positive impact on the teaching and learning process in health professions education, existing assessment methods do not adequately capture the learning that occurs through these games; therefore, more robust and objective assessment tools are needed to accurately evaluate their effectiveness.
(51)	Wingo et al.	2019	United States	Qualitative	Students found the Kaizen game platform highly engaging, particularly valuing team-based competition and educational rewards. The game was reported to enhance knowledge retention and test-taking skills, making it a beneficial tool in fundamental nursing education.
(52)	Hu	2024	South Africa	Qualitative	Game-based learning enhanced acupuncture students' learning experiences and curriculum outcomes by fostering key workplace skills such as teamwork and communication, though its effectiveness is limited by challenges like insufficient feedback, facilitator shortages, and lack of digital game integration.
(53)	Krishnamoorthy et al.	2025	India	Systematic Review	Gamification-based teaching methods significantly enhanced knowledge retention, practical skills, and engagement in pandemic preparedness training for healthcare professionals, although heterogeneity in intervention design and outcome measures limits generalizability.
(54)	Ellaway	2016	Canada	Theoretical/ Conceptual Analysis	Serious games in health professional education can enrich instructional design by incorporating distinct gaming facets—such as competition, simulation, chance, and strategy—offering unique pedagogical value through their structured divergence from real-world practice (an isomorphism) and potential convergence (isomorphism).
(55)	Nylén-Eriksen et al.	2022	Norway	Systematic Review	Game-thinking significantly enhances nursing students' academic achievement—especially in knowledge acquisition—with moderate impact on skill development, making it a valuable strategy for digital-era nursing education.
(56)	Koivisto et al	2016	Finland	Qualitative	Simulation games in nursing education, which feature real-life audiovisual experience, realistic scenarios, and interaction, promote deep experiential learning as students get to apply theoretical knowledge, get feedback to reflect on, and learn procedures—thus, demonstrating the necessity for serious games to have similar engaging characteristics that are typical for leisure games.
(57)	Hope et al.	2022	Australia	Systematic Review	Even though there are numerous instances of gamification implemented in various ways within pharmacy education—from board games to escape rooms and simulations—there are several gaps in the existing literature such as the lack of quality reporting, inconsistencies between the learning objectives and outcomes, and reliance only on students' perceptions that need to be addressed.
(58)	Abou Hashish et al.	2023	Saudi Arabia	Qualitative	Both students and teachers in health sciences education believe that Game-Based Learning (GBL) is a valuable addition to the regular teaching as it promotes motivation and engagement, and at the same time, the implementation of GBL requires certain resources and training from the part of faculty members.

Note: *Descriptive characteristics of the 39 included studies published between 2014 and 2025. The publication trend demonstrates linear growth until 2020, followed by an exponential increase over the subsequent five years.*

Results

The results are organized into two main sections: first, the descriptive characteristics of the included studies (e.g., publication year, geographical origin, journal type, study design, and research domain); and second, the synthesized qualitative themes. The subsequent thematic synthesis provides an in-depth conceptual analysis of the key findings identified across the reviewed literature.

A) Demographic Analyses

Notably, the number of publications on this topic has risen sharply in recent years, with 19 studies published in 2023 alone (Figure 3).

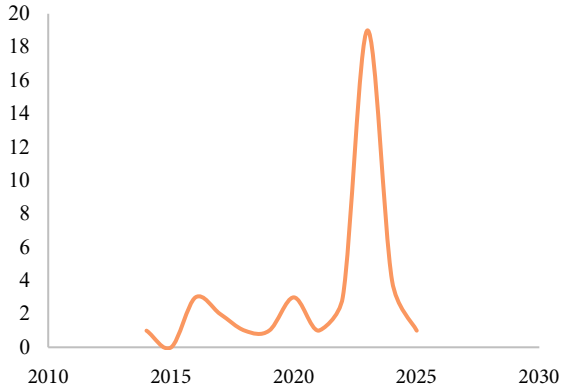


Figure 3. Publication trends in the field of gamification in medical education over the study period

Until the year 2020, the trend regarding the growth in the number of studies has been linear. However, the past five years have witnessed an exponential increase in publication volume. Among the 39 selected studies, systematic reviews were the most frequent design (n=14), highlighting the importance of data synthesis in this field. Another study design is a qualitative study (n=9), suggesting a necessity to explore in-depth the perspective. Other designs, such as narrative reviews and conceptual or theoretical papers, were less frequently represented. The temporal publication trend in gamification within medical education is illustrated in Figure 3. The geographical distribution of the included studies by continent is shown in Figure 4.

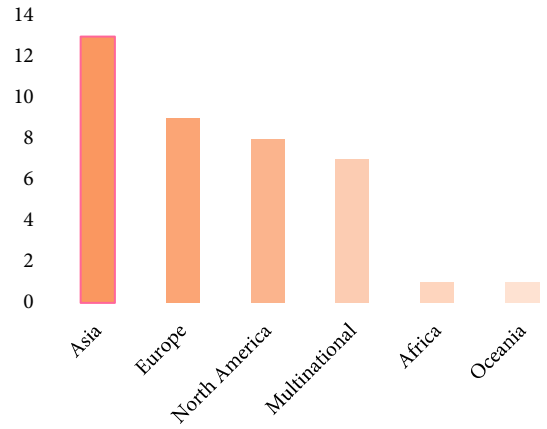


Figure 4. Geographical distribution of gamification studies in medical education by continent

Furthermore, Figure 5 outlines the distribution of studies by research design, providing an overview of the methodological approaches predominant in the literature.

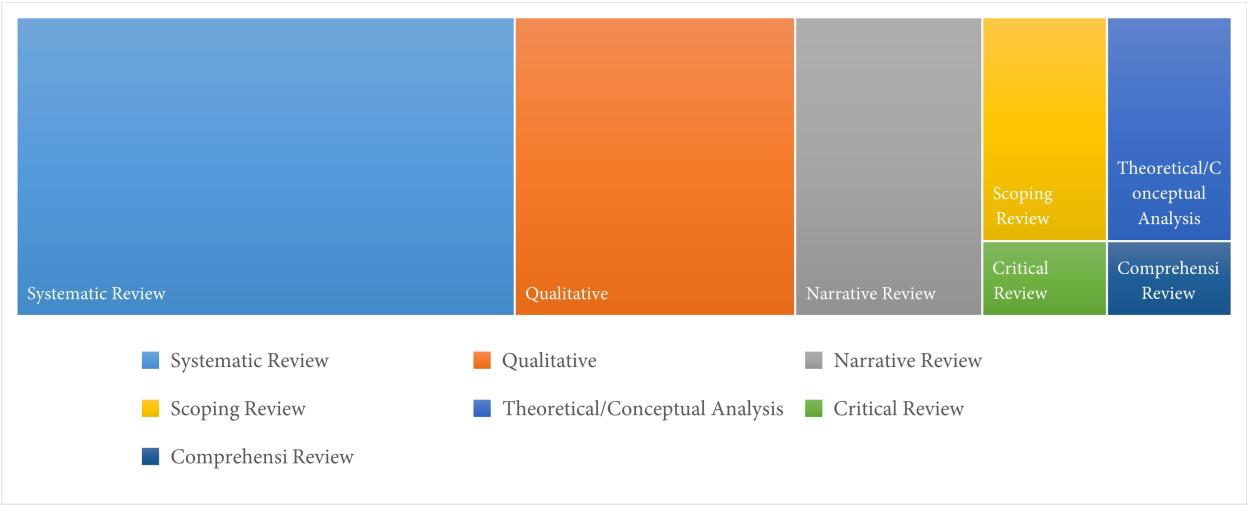


Figure 5. Distribution of gamification studies in medical education by study design

B) Content Analyses

Table 3 presents the findings of the comprehensive thematic and content analysis. All included articles were reviewed in depth and iteratively analyzed by the research team. Relevant concepts and key findings were systematically extracted and categorized in alignment with the study objectives. This inductive synthesis yielded five overarching themes and twenty-two subthemes capturing the multifaceted impact of gamification in medical education.

Table 3. Results of the content analysis of the selected articles

Main Themes	Sub-Themes	Key Concepts
Students	Development of Practical and Cognitive Skills	Clinical Decision-Making Skills (43; 56; 24; 25; 41; 26; 27; 20); Critical Thinking Skills (24; 21; 57; 55; 52; 25; 39; 27; 20); Clinical Competence (21; 49; 36; 25; 20); Cognitive Flexibility (24-; 21; 47; 42); Creativity and Innovation (21; 58; 45; 44; 42; 24); Problem-Solving Skills (21; 49; 47; 45; 43; 57; 25; 26; 29-; 27; 40); Planning and Organizational Skills (21; 52; 43); Practical Skill Development (27; 23; 43; 33; 32; 45; 39; 24-; 28); Self-Efficacy (28; 23; 43; 55); Clinical Reasoning Skills (24; 55; 36; 24; 45); Analytical Skills (57; 31); Professional Skills (31); Multitasking Skills (30; 33); Accountability (35; 50); Self-Awareness and Reflective Practice (35; 42); Digital Literacy (35; 42; 25); Collaborative Awareness (36); Management and Leadership Skills (36; 43; 57; 25); Analytical Decision-Making Capacity (36); Interpersonal and Communication Skills (40; 53; 45; 57; 52; 36; 20; 32; 24-; 21; 24); Emotional Skills (43); Interpretive Analysis Skills (43; 45); Metacognitive Skills (44); Adaptability (49); Cultural Competence (50); Tolerance for Ambiguity (53); Conflict Resolution Skills (54); Professional Identity Formation (54); Empathy (54; 57); Systems Thinking (55); Time Management (58); Stress Management (33; 21; 49; 45; 43; 42); Team-Building and Teamwork Skills (23; 45; 55; 52; 30; 57; 25; 43; 51; 38; 33; 31; 26; 21); Sense of Belonging (36; 49; 42).
	Enhancement of Motivational and Academic Levels	Satisfaction Enhancement (23; 55; 41; 28; 45; 25; 33; 32); Sense of Achievement (38; 26); Academic Performance Improvement (32; 50; 45; 43; 54; 38; 36; 35); Knowledge Acquisition (23); Mastery of Course Content (40); Opportunities for Practicing New Procedures (27); Deeper Understanding of Course Material (27); Learner Confidence Enhancement (27; 52; 30; 45; 39; 38; 33); Provision of Unique Learning Experiences (28); Unlimited Access to Educational Resources (34); Opportunities for In-Depth Study in Selected Areas (43); Encouragement of Student Engagement in Study (48); Opportunities for Deliberate Practice in Medicine (36); Opportunities to Improve Content Comprehension (36); Provision of Personalized Learning Opportunities (37); Extracurricular Learning Opportunities (43); Competitive Spirit Enhancement (36; 28; 42); Improvement in Knowledge Retention (31; 21; 50; 39; 44; 23); Assistance in Assignment Completion (24-; 22); the Gap Between Theoretical Knowledge and Real-World Application (24; 39; 53); Support for Learners in Analyzing Their Academic Progress (26); Support for Students in Gaining Professional Knowledge on Behavior and Interaction in Advanced Medical Settings (34); Facilitation of Difficult Task Execution (20); Support for Applying Medical Theories (56; 20); Assistance in Understanding Various Academic Topics (39); Self-Esteem Enhancement (21; 42)
	Preparation for Real-World Practice	Preparation for Technological Aspects of Innovative Practices (51); Readiness for Changes in Clinical Patient Presentation (51); Real-World Preparedness (51); Enhanced Readiness for Crisis Management (33; 53; 49; 30); Ability to Observe the Consequences of Decision-Making (24; 56; 24); Preparedness for Real-Life Situations (28); Exposure to the Pressure and Urgency of Medical Decision-Making (29-); Improved Readiness for Examinations (48);Support for Real-World Decision-Making (21;53); Enhanced Accuracy in Diagnostic and Therapeutic Decisions (21;30;49;47;45;20).
Faculty Members	Advancement of Teaching Techniques	Facilitating Storytelling in Education (21; 33; 22); Tailored Instruction (21; 35; 42); Creation of New Educational Concepts (21); Wider Range of Educational Settings (24); Educational Innovation (40; 46; 42; 36; 24; 52); Better Accomplishment of Educational Goals (33; 28; 36); Addressing Various Educational Needs (25; 24); Development of Instructional Approaches (32); Importance of Educational Subjects (33); Low-Cost and Simplified Instruction (36; 33; 44); Educational Materials Development (33); Game Based Learning Style Adaptation for Clinical Settings (34; 35); Establishing Educational Objectives (35); Competency Based Education (36); Creating the Desired Educational Outcomes (36); Educational Activities Enhancement (36); Learning Process Oriented to the User (37); Diversity of Teaching Strategies (37); Combination of Games with Educational Objectives (38); Help in Formulating the Final Teaching Objectives (38); Learner-Oriented Instruction Delivery (25); Focused Instruction Content Delivery (25); Consistency with Educational Concepts and Theories (41); Breaking down the Content into Small Parts (42;

Main Themes	Sub-Themes	Key Concepts
		40); Excellent Way of Teaching Abstract Principles (44); Learner-Focused Pedagogy (43); Integration of Gaming Techniques in Repetitious and Boring Activities to Encourage Change (46); Engaging and Efficient Pedagogical Strategy (47); Integrating Competitiveness and Educational Goals (47); Established Pedagogical Frameworks (47); Used as an Auxiliary Teaching Technique (48; 27); Flexible Learning (49); Better Transfer of Academics (53); Aid to Instructors in Recognizing Instructional Mistakes (58); Aid to Instructors in Spotting Difficulties in Students' Learning Process (58); Helps in Segmenting the Class (38).
	Design and Development of Educational Activities	Design of Challenge-Based Learning Activities (40; 58; 45; 54; 20); Design of Specific Activities (45; 20); Design of Customized Assignments (21); Help in the Design of Assignments (40; 24; 45); Design of Interactive Assessments (36; 33; 24); Development of Learning Outcomes (40; 42); Design of Assignments (58); Design of Interactive Media Projects (21); Design of Novel Pedagogical Approaches (33; 31; 21; 44; 24); Design of Educational Activity Reviews (26).
	Support for Skills Development	Enhancing Communication Skills (25; 58; 52; 20); Enhancing Collaborative Decision-making Skills (36; 56; 29); Helping the Faculty Identify the Areas Where They Have to Improve (26); Contributing to the Generation of the Existing Knowledge (26); Enabling the Creation of New Knowledge (26); Improving Mentoring Skills (26); Giving Faculty a Platform to Express Their Ideas and Work Together (44); Enhancing Subject Matter Knowledge (50); Increasing Technological Awareness of the Faculty (58).
Teaching and Learning Processes	Simulation and Intelligent Learning	Simulation-Based Clinical Education (41; 32; 26; 27; 55; 47; 45; 24; 25; 20); Visual Learning (20); Blended Learning (21; 20); Narrative Learning (21; 22); New Techniques Learning (26); Increased Effectiveness of VR and AR Application (26; 45; 47; 37; 33); Multimedia Learning Process (35
	Personalization and Autonomy in Learning	The education process can be personalized (34; 47; 45; 38; 24); active learning strategies can be employed (27; 24; 47; 56; 45; 43; 36; 24; 57; 58; 34; 32); models of individualized learning processes may be developed (32); the self-reflection process may be encouraged (33); the preferences of the students can be paid much attention to (36); students can be motivated to learn actively, providing them with the opportunity to select the best and the most convenient way for them to learn (38); it is important to allow students to face failures and learn how to overcome the fear of failing (38); learning can be organized according to student's interests (25); the best way of learning can be aligned with students' competences (25); and students can be given a possibility for independent learning (40; 56; 26; 44; 42; 28).
	Experiential Learning	Learning that is interactive (36; 30; 38; 25; 20); learning through experience (26; 31; 56; 24; 21; 52; 45; 42; 40); authentic learning that is better (21; 47; 36; 35; 28); mixing and matching learning experiences (26; 47; 36; 24); the design of games in order to maximize learning (41); learning by trial and error (47; 52); learning by solving problems (24); the modeling of learning on solving problems (31); learning through solving cases (31; 49); repeated experience in learning (44); exploratory learning (43).
	Development of Learning Environments	The possibility of integrating with learning systems (20); the creation of positively competitive learning conditions (21; 48; 47); the formation of a secured and regulated environment for learning (26; 30; 45; 42; 38; 51); an immersive environment of education (47); the generation of networked educational processes in the ambiance of studying (21; 43; 20); the rise of motivation both in intrinsic and extrinsic terms in the realm of learning (40; 58; 53; 50; 55; 46; 45; 42; 37; 28; 27; 29; 21; 22; 20; 32); an entertaining and joyful environment of learning (21; 57; 52; 30; 49; 48; 45; 46; 39; 38; 44; 42; 25; 32; 36; 35; 33; 26; 24; 31; 22); the provision of innovative solutions using games in study environments (35); the connection of educational objects and educational opportunities (35); an accountability-based learning environment (38); a friendly learning environment (41).

Main Themes	Sub-Themes	Key Concepts
	Enhancement of Learning Effectiveness	Conceptual Learning (39; 21; 52; 42); Improvement of Learning Quality (34; 47; 20); Assistance in Learning Analysis (20); Variety in Learning Activities (20; 52); Getting Success in Learning (40; 50; 30; 20); Authentic Learning (21; 20); Accessibility of Learning Opportunities (43; 32; 20; 54); Competency-Based Learning (20; 21); Independent Learning (45; 20; 40; 41; 56); Improvement of Learning Activity (21; 28; 40); Improving Learning Attitudes (28; 46; 22; 35; 43); Efficient Learning Time (38; 58; 23); Effortless Learning (23); Reverse Learning (23); Target Learning (40); Slow Learning (40); Learning Organization (40); Interesting Learning Experience (51; 27; 42); Improved Situation Awareness (27); Version of Learner's Capabilities (27); Group Learning (51; 27; 45; 42; 43; 28); Update of Learner's Knowledge during Learning (28; 43); Improvement of Good Learning Results (33; 26; 52; 50; 48; 25; 38; 28); Engaging the Learner in Learning Process (32; 24); Using of the Learner's Cognitive Structures (26; 52; 43); Group Learning (26); Learner's Active Participation in Learning (51; 53; 30; 46; 39; 25; 42; 41; 38; 33); Improvement of Learning Capability (32); Learning Well (35; 21); Learning Successfully (35); Improving Concentration while Learning (35; 25); Learning through Competition (38); Learning Organization (25); Learning Support with Multi-Faceted Approach (42); Learning outside the Classroom (42); Profound Learning (44); Peer Learning (58;43); Learning through Competition (58; 48); Learning Facilities Development (50); Creative Learning (50); Development of Learning Styles (50); Implicit Learning (30); Emergent Situations Organization (54); Purposeful Learning (55); Adapting to Learning Needs of New Generation. (58)
Assessment	Design of Assessment Procedures	Design of Feedback Systems Based on Scoring Mechanisms (40); Design of Competitive-Style Feedback and Reward Systems (26); Design of Fair Reward Systems in Assessment (38); Implementation of Feedback Mechanisms within a Game Framework (38); Creative Methods in Test Design (38); Design of Short Assessments (36; 42); Utilization of a Wide Range of Evaluation Mechanisms in Design (25); Competitive Rewards in Assessment (42)
	Development of Assessment Procedures	Support for the Targeted Use of Feedback (21; 40); Development of Performance Dashboards for Assessment (29); Development for the Evaluation of Complex Clinical Activities (51); Development for Test Correction (33); Development for Diversifying Reward Systems in Assessment (33; 43); Development of Scoring Systems in Evaluation (35); Development for Identifying Areas for Improvement in Assessment (47); Design of New Assessment Protocols (49).
	Targeted Feedback	Feedback based on learning styles (20); Peer feedback (20); Sequential feedback (31; 41; 21); Reformulated feedback system (21); Prompt feedback (23; 21; 30; 47; 46; 38; 33); Immediate feedback (27; 53; 36; 26; 35; 24); Instant feedback (26; 27; 24; 56; 30; 43; 25; 38; 45; 41; 51; 24); Customized feedback (29); Modifying feedback (24); Joint evaluation (26); Enhanced validation quality (26); Pre-education testing (36; 33; 58; 47); Assistance for student self-evaluation (35; 56; 36); Peer critique (36); Monitoring progress of students (36); Visual critique (37); Performance critique from peers (38); Student grading (38); Objective feedback form (47); Evaluation improvement (47); Evaluation on ongoing basis (48); Qualitative critique (48); Interactive evaluation (30; 53); Feedback that is meaningful (52); Evidence-supported feedback (53).
Curricula	Curriculum Design	Curriculum Update (20) Reality-Oriented Curriculum (21); Implementation of Game Dynamics in Curriculum (55; 33); Individualized learning approach (44); Curriculum Representation (43); Assistance in Curriculum Creation (55)
	Curriculum Enhancement	Curriculum Development that Reflects the Growth of Student Involvement in Course Material (21; 24); Modification of Curriculum Content Intensity (50); Development of Interactive Course Material (58; 53); Improvement and Enhancement of the Curriculum (32); Converting Course Material into a Competition (38); Making Course Content Interesting (39; 53); Assisting in Curriculum Review (55); Digital Curriculum Development (58)

Note: *Results of the inductive content analysis illustrating the five main themes, twenty-two subthemes, and constituent key concepts mapped across the included literature, with source study citations*

Subsequently, Shannon's entropy method was applied to calculate the objective weight and relative importance of the identified themes and dimensions. Grounded in information theory, Shannon's entropy is a robust multi-criteria weighting technique that quantifies the informational significance of synthesized categories. This approach evaluates the distribution and frequency of codified concepts across the analyzed dataset. By quantifying the information load and degree of dispersion, this method establishes the relative weight and prioritization of each conceptual category.

Equation 1. Shannon Entropy Formula

$$E_j = -k \sum_{i=1}^{m} P_{ij} \times \mathrm{Ln}\ P_{ij} i = 1.2. \ldots . mk = \frac{1}{\mathrm{Ln}\, m}$$

$$W_j = \frac{d_j}{\sum d_j} d_j = 1 - E_j$$

Table 4 presents the relative weight of each extracted main theme.

Table 4. Applications of Gamification in Medical Education Based on the Shannon Entropy Technique

Applications of Gamification in Medical Education	Normalized value	Value (E)	Degree of Diversification	Value (W)	Steps for Applying the Shannon Entropy
Students	0.322	0.903	0.097	0.054	First, identify and categorize the indicators and components extracted from the documents or texts; Determine the frequency of each indicator in the content under study; Apply the Shannon Entropy formula to the identified indicators; Determine the importance of each indicator using the formula; Finally, calculate the final weights of the indicators to identify which ones have greater importance in the analyzed content.
Faculty Members	0.140	1.360	0.360	0.201	
Teaching and Learning Processes	0.395	0.821	0.179	0.227	
Assessment	0.114	1.273	0.273	0.152	
Curricula	0.051	1.879	0.879	0.491	

Note: *Application of the Shannon Entropy Technique quantifying the normalized values, degree of diversification (EEE), and informational weights (WWW) for each of the five .main dimensions of gamification in medical education*

While simple frequency analysis quantifies the prevalence of specific themes, it only reflects the raw volume of qualitative data. In contrast, Shannon's entropy method considers both the frequency of occurrence and the distributional diversity of these themes across the included studies. It measures the level of uncertainty (entropy) for each dimension and normalizes the results, giving higher scores to dimensions with greater informational uniformity. For instance, the 'Curricula' dimension yielded the lowest raw frequency but attained the highest objective weight (W = 0.491), owing to its consistent distribution across the dataset. Conversely, the 'Students' dimension exhibited the highest frequency but a lower weight (W = 0.054), reflecting a high concentration of data within specific clusters. These findings underscore the utility of Shannon's entropy in surfacing dimensions of high informational significance that might otherwise be overlooked by frequency analysis alone.

Discussion

This meta-synthesis analyzed evidence from 39 studies that identified major educational applications of gamification in medical education.

Five core dimensions emerged: students, educators, teaching and learning processes, assessment, and curricula. Notably, Shannon's entropy analysis revealed that the 'Curricula' dimension, despite having the lowest citation frequency, carried the highest informational weight (W = 0.491), even though it was the least frequently used one. Thus, the strategic use of gamification within the curricula is the main driver of success. In turn, the students' dimension that was used most frequently contained the lowest diversity of ideas (W = 0.054), which means that positive information may be superficial.

A) Students

In our synthesis, the 'Students' theme emerged as the most frequently reported dimension. While such prominence is anticipated in a learner-centered discipline, its comparatively low weight in the Shannon entropy analysis (W = 0.054) suggests that, despite extensive discussions on student achievement and performance, the underlying discourse exhibits limited thematic diversity. The influence of gamification on student motivation and skill acquisition is theoretically grounded in Self-Determination Theory (SDT) (60). Gamification mechanics—such as points, badges, and progress bars—can satisfy the core psychological needs of competence, autonomy, and relatedness (61). Our findings demonstrate that gamification fosters the development of critical thinking and clinical decision-making skills (20, 22, 24, 26, 28, 30, 32, 34, 36, 38, 40, 42).

These findings align with the meta-analysis by Zhao et al. (34), which corroborated the efficacy of serious games and digital gamification in enhancing learning outcomes. However, while Salehi et al. (30) reported that

the vast majority (90%) of studies yielded positive outcomes, our entropy analysis suggests that this prevailing optimism may mask a lack of critical depth in the literature. Specifically, many existing studies overlook disparities in baseline digital literacy among learners. Failing to account for variations in digital competencies and equitable resource access may inadvertently exacerbate learning disparities and undermine instructional efficacy.

B) Faculty Members

The 'Faculty' theme was also assigned a significant weight (W=0.201) in the entropy analysis. The efficacy of gamification techniques is heavily contingent upon the pedagogical expertise of faculty members and their ability to integrate game mechanics in alignment with specific learning objectives (62). This theme was operationalized through several key codes, specifically regarding instructional design, evaluation, and communication (20, 22, 24, 26, 28, 29, 32-50, 52-54, 56, 58). Within a gamified framework, the instructor's role shifts from being the "sage on the stage" to the "guide on the side." Furthermore, faculty involvement is essential for both content development and the subsequent analysis of learning outcomes.

Our findings corroborate the observations of van Gaalen et al. (22), who identified a deficiency in theoretical grounding and the use of robust control groups in existing gamification literature. We extend these conclusions by suggesting that such methodological shortcomings may stem from inadequate faculty training in game-based pedagogy. Previous reviews, such as that by Bigdeli and Kaufman (43), have underscored the necessity for standardized classifications. Our findings suggest that the potential benefits of these standardized classifications may remain unrealized unless accompanied by robust faculty development programs. Failure to prepare faculty usually leads to surface-level gamification (such as implementing leaderboards without being fully aware of their purpose in education). Utilizing extrinsic motivators in isolation from core educational objectives may foster superficial engagement without facilitating substantive learning.

C) Teaching and Learning Processes

This theme exhibited both high frequency and substantial informational weight (W=0.227), underscoring its central importance to the synthesized literature. Game-based learning—incorporating simulations, virtual reality, and intelligent tutoring systems—offers a "sandbox" environment that enables learners to explore through iterative success and failure, without the real-world clinical repercussions associated with medical errors (26, 31, 56). In the medical domain, such safe-to-fail environments are critical, as clinical errors in practice can have significant adverse consequences. Furthermore, the 'Personalization' subtheme (34, 47) aligns with the preferences of digital natives, who increasingly prioritize learner autonomy and efficient, self-paced learning pathways.

Our findings corroborate the narrative review by Xu et al. (36), which emphasizes that game-based learning facilitates immersive experiences through integrated feedback loops and active learner participation. However, whereas Xu et al. (36) primarily focused on technological affordances, we argue that the elements of "fun" must not overshadow core pedagogical objectives. According to Van Gaalen et al. (40), play and learning may be seen by students as being at loggerheads, which indicates the necessity to approach their combination carefully in order to achieve success through gamification. Learning will not change if it just borrows some game elements without rethinking the whole process. It is gamification alone that does not provide the solution to the issue of critical thinking development; it is to complement theoretical learning.

D) Assessment

The 'Assessment' dimension received a high informational weight (W=0.152), underscoring its pivotal role in gamified medical education. Traditional assessment methods frequently prioritize rote memorization. Gamification facilitates continuous formative assessment through real-time dashboards, instantaneous feedback loops, and advanced performance analytics (63). This is effectively exemplified by "stealth assessment," a technique that seamlessly integrates evaluation into the learning process (64). Furthermore, gamification supports the simulation of complex clinical scenarios, enabling the evaluation of higher-order cognitive abilities, such as critical thinking and ethical reasoning (20, 24, 26, 29, 30, 33, 35-37, 39, 40-43, 45-49, 51-53, 56, 58).

While scholars such as Abdulmajed et al. (50) contend that current evaluation systems often fail to capture learning gains in game-based environments, our findings suggest that modern gamified frameworks are beginning to mitigate these limitations. Nevertheless, rigorous research remains necessary to establish the psychometric validity and reliability of assessments across diverse gamified platforms. The absence of innovative assessment modes threatens to undermine the potential of gamification to foster deep knowledge consolidation.

E) Curricula

Notably, the 'Curricula' theme exhibited the lowest raw frequency yet yielded the highest informational weight (W=0.491) in the Shannon entropy analysis. This suggests that while curricular integration is reported less frequently in the literature, the associated conceptual discourse is multifaceted and substantive. The curriculum serves as the foundational architecture for all other educational components. As McCoy et al. (20) posited, gamification must function as an integral element of the curriculum rather than an isolated instructional method. Although effective curricular design necessitates systemic thinking, existing curricula are often characterized by institutional rigidity and resistance to innovation. Our findings align with the theoretical framework proposed by Ellaway (54), who argued that serious games provide unique value by creating experiential spaces distinct from real-world clinical practice. While Ellaway primarily examined the nuances of game design, our synthesis indicates that the challenges of integration extend to broader educational and socio-structural contexts.

Neglecting the requirements for systemic curricular integration creates significant barriers to the effective adoption of gamification. Failure to align gamified interventions through curriculum mapping can lead to pedagogical misalignment and impede the accurate assessment of learning outcomes. Some studies indicate that despite successful localized implementations, gamification often remains at the periphery of medical curricula, lacking the structural pathways required for comprehensive integration (65, 66).

F) The Realities of Implementation: Localization Challenges in Developing Countries

While the identified dimensions are conceptually applicable across diverse settings, their practical implementation is heavily contingent upon specific local contexts. Examining gamification implementation at the local level necessitates an analysis of systemic barriers related to educational structures, cultural norms, and the distinct challenges facing developing nations. Cultural factors warrant particular attention; in many developing regions, entrenched traditional pedagogies persist, often leading to the perception of gamification as mere entertainment rather than a legitimate learning strategy. As Sambo et al. (67) noted, despite growing interest among students and faculty, significant structural and cultural barriers often impede implementation. Furthermore, institutional constraints—including rigid classroom configurations, inflexible scheduling, and environments unsupportive of game-based approaches—constitute major implementation barriers (68). Technological and Infrastructural Barriers: Developing nations often face critical technological disparities. These challenges include limited internet connectivity, high data costs, reliance on obsolete hardware, and a lack of specialized gamification software (67). The Fuzzy Analytical Hierarchy Process identified the primary barriers as: insufficient equipment, lack of technical expertise, financial constraints, inadequate infrastructure, and a scarcity of validated game-based pedagogical methods (68). These barriers collectively impede implementation, largely due to the prohibitive financial investment required. Institutional and Faculty Capacity: Institutional constraints—such as rigid curricula, unfavorable faculty-to-student ratios, and ineffective policy frameworks—frequently hinder gamification adoption (67). Faculty members operating within such environments often lack the specialized training necessary to design effective gamified initiatives (69).

Consequently, the successful adoption of gamification in developing countries requires shifting away from a "technology transfer" model. Instead, a "glocalization" approach is essential to adapt global technological frameworks to the specificities of local contexts. Recommended strategies include: (a) engaging local stakeholders in the design process; (b) leveraging mobile technologies compatible with local infrastructural capacities; (c) designing faculty development programs tailored to regional needs; and (d) developing cohesive national and institutional policies for gamification in higher education.

Several methodological limitations merit acknowledgment. First, restricting our search to English-language publications may have introduced language bias, potentially omitting significant research disseminated in local languages, particularly in regions with robust non-English medical education scholarly traditions. Second, while our adaptation of the CASP checklist for systematic and narrative reviews was necessitated by the conceptual and qualitative nature of the evidence, this represents a pragmatic adaptation of a tool originally designed for primary qualitative studies. To enhance methodological focus, we prioritized five CASP-derived indicators: (a) clarity of research aims; (b) transparency and rigor of methodology; (c)appropriateness of the qualitative approach; (d) credibility of the analytic synthesis; and (e) practical applicability and transferability of the findings. Despite this focus, such adaptations inherently introduce a degree of subjectivity not present in the tool's original application. Third, the pragmatic decision to limit

Google Scholar searches to the top 200 results, while justifiable for reducing retrieval noise, warrants critical reflection regarding potential selection biases. Google Scholar's ranking algorithm is opaque and non-reproducible, as it dynamically integrates citation metrics, user profiles, and geographic data, potentially favoring highly-cited older publications while excluding newer or niche scholarship. Furthermore, the platform's inconsistent handling of duplicate records (e.g., preprints, repository copies) may prioritize non-peer-reviewed versions over final publications, complicating the appraisal process. While the marginal yield of relevant studies is expected to decline substantially in the "long tail" beyond the first 200 results, this cut-off does not guarantee the complete absence of pertinent articles; rather, it represents a pragmatic compromise between comprehensiveness and screening feasibility, acknowledging that exhaustive retrieval would demand considerable effort with diminishing returns. Fourth, the search conducted in March 2025 creates an inherent temporal limitation, as studies published subsequent to this date were not included in the synthesis. Fifth, the high proportion of review articles (n=14) reflects the field's relative immaturity, which precludes causal inferences and underscores the need for primary experimental studies utilizing robust control groups. Finally, as in all qualitative syntheses, the meta-synthetic process involves interpretive subjectivity; however, we mitigated this risk through investigator triangulation and peer debriefing.

Conclusion

This meta-synthesis identified five core thematic dimensions through which gamification intersects with medical education: student development, faculty engagement, teaching-learning processes, assessment, and curriculum design. Our findings indicate that gamification can bolster academic performance, cognitive proficiency, and clinical readiness, while offering significant potential for instructional innovation, faculty development, and formative assessment. A particularly noteworthy finding is the pivotal importance of the 'Curricula' dimension. Despite being the least frequently reported theme in the existing literature, Shannon entropy analysis assigned it the highest informational weight (W = 0.491). This suggests that systemic curricular integration is a more critical—yet underexplored—determinant of successful implementation than isolated technological interventions or superficial motivational techniques.

The present synthesis cautions against overgeneralizing these findings. Given the inherently interpretive nature of meta-synthesis, these findings do not establish causal relationships but rather provide a conceptual framework to guide future research and practical implementation. Methodological limitations—including the English-language restriction, the pragmatic adaptation of the CASP tool, the search constraints applied to Google Scholar, and the March 2025 search cutoff—should be considered when interpreting these conclusions. Consequently, future empirical research should prioritize robust, controlled studies that investigate the impact of gamification on clinical performance—particularly in underrepresented regions (e.g., Africa and Oceania)—and explore strategies to align game design with long-term curricular objectives.

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Conflict of interests: There is no conflict of interest.

Ethical approval: This study is a comprehensive review of the existing literature. No original experiments involving human participants or animals were conducted by the authors. Consequently, the procurement of an ethical code or institutional review board (IRB) approval was not applicable to this work.

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Data Availability: This is a review article. No new data were generated or analyzed. All data discussed were derived from publicly available sources.

Artificial Intelligence (AI) Usage Declaration: Generative AI tools were used solely to assist with summarizing relevant articles and drafting/editing English text. All AI-assisted outputs were carefully reviewed, verified, and revised by the authors. The authors supervised the entire process and take full responsibility for the content, accuracy, and integrity of the manuscript. AI tools were not used to generate original research data, interpret results independently, or replace authors' scientific judgment. AI tools are not listed as authors.

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