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Review

Implementation Strategies for Gamification in Pharmacy Clinical Skills Education: A Review and Practical Implications

Bo Han[1,2], Yulin Zhao[2], Nur Wahida Zulkifli[1,*]

[1]Faculty of Pharmacy, Universiti Teknologi MARA, Puncak Alam, SGR 42300, Malaysia
[2]Faculty of Medicine, Zhangjiakou University, 075000 Zhangjiakou, Hebei, China
*Correspondence: wahidazulkifli@uitm.edu.my (Nur Wahida Zulkifli)
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Abstract

Gamification has emerged as an innovative pedagogical strategy with considerable potential to enhance competency development in health professions education. However, its systematic integration into pharmacy clinical skills training remains underexplored. This review systematically synthesises current evidence on the design principles, theoretical foundations, and educational outcomes of gamified learning in pharmacy curricula. Particular emphasis was placed on its influence on learner motivation, knowledge retention, clinical reasoning, and interprofessional collaboration. A comprehensive literature search encompassing pharmacy, medical, and health sciences education was conducted to identify core components and best practice frameworks for effective gamification. Evidence indicates that well-designed gamification models can significantly improve learner engagement and promote the meaningful integration of theoretical knowledge with authentic clinical practice. Nonetheless, several barriers, including limited instructional resources, inadequate faculty expertise, underdeveloped evaluation tools, and ethical concerns related to data security and digital equity, continue to constrain widespread implementation. This review proposes actionable strategies such as precise alignment of gamification elements with course objectives, structured faculty capacity building, enhancement of technological infrastructure, adoption of multidimensional evaluation systems, and strengthened interprofessional collaboration. Future research should focus on adaptive, artificial intelligence (AI)-driven gamification approaches, evaluate their long-term impacts on clinical competence, and develop standardised, evidence-based guidelines for sustainable integration, as outlined in the proposed frameworks within this review.

Keywords: gamification; pharmacy education; clinical competence; educational technology

1. Introduction

As global healthcare transitions from disease-oriented interventions to holistic, patient-centred care, the professional role of pharmacists has become increasingly pivotal within multidisciplinary teams. Pharmacists are now expected not only to have extensive pharmacological expertise but also to demonstrate a wide range of competencies, including prescription verification, personalised medication counselling, pharmacovigilance, and effective interdisciplinary communication [1]. The increasing complexity of clinical scenarios, combined with the diverse needs of patients, has imposed substantial new demands on the competency framework of pharmacy professionals [2].

Traditional pharmacy clinical skills training still depends heavily on didactic instruction and laboratory-based exercises, offering limited opportunities for immersive, context-rich learning. Such approaches often result in low learner engagement and inadequate progress in higher-order thinking or integrative problem-solving skills essential for real-world clinical practice [3]. Moreover, assessment frameworks remain predominantly oriented toward factual recall and basic procedures, frequently overlooking the development of analytical reasoning, decision-making capacity, and collaborative competence [4].

Within this evolving educational landscape, gamification, defined here as the strategic incorporation of game mechanics such as challenges, rewards, feedback, and collaboration into non-game contexts to enhance engagement [5], has emerged as a promising pedagogical approach in pharmacy education. To clarify key distinctions, serious games are fully developed games designed for educational purposes (e.g., web applications for memorising drug classifications and properties), while game-based learning employs games as the core instructional method, such as simulations used to teach drug interactions within pharmacy curricula [6,7].

Evidence from broader health sciences indicates that thoughtfully designed gamification can markedly enhance learner motivation, strengthen knowledge retention, promote transfer of skills, and improve clinical reasoning capabilities [8,9]. In pharmacy-specific applications, gamification has yielded targeted benefits; for instance, such approaches have been shown to enhance mastery of pharmacology knowledge (63.5%), increase student engagement (61.9%), and strengthen autonomous learning abilities (74.6%) [10]. Similarly, in a gamified tool focused on best practices for chemotherapy drug preparation, 18 out of 24 participants reported being highly satisfied with

the knowledge acquired through ChemINJ, and 23 participants expressed interest in replaying the module [11]. However, adoption in pharmacy education remains constrained by limited faculty expertise in gamification design, inadequate technological infrastructure, and scarce resource platforms [5].

Although the benefits observed in related health disciplines highlight significant potential, systematic and domain-specific investigations in pharmacy education remain limited. Against this background, the present review aimed to comprehensively analyse existing practices, educational outcomes, and implementation strategies of gamification in pharmacy clinical skills training, providing an evidence-based foundation for optimising instructional models.

2. Pedagogical Foundations and Core Characteristics of Gamification

2.1 Clear Learning Objectives and Regulatory Framework

Effective gamification design necessitates the precise alignment of instructional goals with a coherent, rule-based framework [5]. In the context of pharmacy clinical skills training, this involves translating abstract competency standards into concrete, measurable, and contextually relevant learning tasks. For example, the competency of prescription review can be operationalised into three progressive subtasks: (1) identifying potential medication-related risks, (2) developing corrective strategies, and (3) communicating effectively with a simulated physician. Each subtask should be guided by explicit performance benchmarks and supported by structured, timely feedback mechanisms [12]. Such task decomposition not only clarifies the intended learning trajectory for students but also enhances the precision and objectivity of instructors' assessments.

The rules framework represents another cornerstone of gamification, defining task boundaries and operational guidelines to maintain equilibrium between engagement and educational purpose [13]. Without such structure, gamified activities risk devolving into recreational exercises that undermine their educational objectives. In pharmacy education, this may involve mechanisms such as time limits, information-access limitations, and transparent scoring rubrics to promote active engagement within a pedagogically sound environment [14]. For instance, in a pharmacy-specific gamified module on drug discovery, clearly defined objectives were paired with rule-based subtasks, such as molecular identification and synthesis planning, leading to measurable improvements in the entrepreneurial competencies of students [12]. Based on our synthesis, this alignment is crucial in pharmacy education, where regulatory compliance (e.g., Food and Drug Administration [FDA] guidelines) mirrors real-world professional contexts, thereby enhancing authenticity and instructional efficacy.

2.2 Continuous Challenge and Immediate Feedback

Challenge functions as a primary intrinsic motivator for sustained learning. In pharmacy clinical skills education, task difficulty should be progressively increased, for instance, through more complex patient cases, integration of simulated emergency scenarios, or implementation of tighter time constraints [15]. In pharmacotherapy planning exercises, scenarios involving comorbidities, pregnancy, or organ impairment can be introduced to compel learners toward integrated, multidimensional decision-making.

Immediate feedback plays a crucial role in skill internalisation [16]. Empirical evidence indicates that delayed feedback reduces the capacity of learners to correct errors, whereas real-time feedback enables *in-situ* cognitive adjustment, thus reinforcing deep learning and long-term knowledge retention [17]. In a gamified pharmacy class, feedback may be provided automatically through digital analytic systems or directly by instructors and peers, creating a continuous learn-apply-refine cycle [18]. For example, in a pharmacy clinical skills training game such as "Decision-Making Cards", challenges escalate from basic drug interaction identification to complex polypharmacy management, with immediate artificial intelligence (AI)-driven feedback explaining error mechanisms and suggesting corrective actions. This approach has been shown to enhance student confidence in prescribing tasks [19]. In our view, this feature directly addresses the pharmacy's unique need for rapid error correction in high-stakes environments, such as medication dispensing, potentially reducing real-world adverse events more effectively than static feedback mechanisms.

2.3 Reward Systems and Achievement Motivation

Reward mechanisms are fundamental to sustaining learner engagement in gamified environments [14]. In pharmacy training, these may include point accumulation, level progression, achievement badges, or leaderboard rankings, each explicitly linked to defined course learning objectives [20]. For example, during simulated medication counselling, high-performing students could gain access to advanced case materials or leadership opportunities within team assignments, thereby transforming extrinsic motivators into catalysts for deeper learning and skill mastery.

However, research cautions that misaligned reward systems, or designs neglecting learner diversity, may inadvertently weaken intrinsic motivation [21]. Therefore, gamified reward structures must balance short-term incentives with long-term competence development, employing periodic reinforcement to maintain enthusiasm and build self-efficacy through mastery experiences [22]. A specific case in pharmacy involves badge systems in self-care pharmacotherapy courses, where rewards for accurate counselling unlock advanced modules, resulting in greater motivation and improved knowledge retention [8]. From our perspective, reward mechanisms in pharmacy gamifica-

tion should prioritise intrinsic growth over competition to align with the ethical foundations of patient-centred care. This emphasis distinguishes pharmacy from other gamified health education disciplines, such as nursing, where competitive incentives may be more prevalent.

2.4 Social Collaboration and Cooperative Competition

Pharmacy practice is inherently interdisciplinary, requiring close collaboration with physicians, nurses, patients, and other healthcare stakeholders. Gamified learning activities that incorporate social interaction components effectively emulate such workplace dynamics, enabling students to develop communication and teamwork skills in a low-risk environment [1,23]. For instance, in a team-based drug-dispensing competition or a virtual ward decision-making exercise, learners may be assigned distinct professional roles, such as prescription reviewer, patient counsellor, or drug information specialist, and tasked with achieving a shared objective under time constraints. These activities not only strengthen team coordination but also enhance professional role literacy through systematic role rotation [24].

A cooperative-competition model can be equally beneficial. Evidence suggests that collaborative yet gamified activities improve both technical and non-technical competencies [13]. However, competitive elements should be applied judiciously, as excessive pressure may induce performance anxiety and impede learning [25]. A balanced approach involves prioritising cooperation while embedding manageable competitive elements, such as combined team rankings with intra-group peer rewards, thus preserving competitive motivation while reinforcing collaborative values [26]. In pharmacy, the "International Pharmacy Game" exemplifies this approach, where international teams collaborate on dispensing challenges using cooperative scoring systems, improving interprofessional skills across seven universities [23]. We argue that this model is especially suited for pharmacy training, as it reflects the multidisciplinary nature of healthcare teams and promotes equity in global education contexts beyond individual professional silos.

2.5 Technological Platforms and Immersive Experiences

Modern gamification in pharmacy education leverages emerging digital technologies to create immersive, multimodal learning environments. Tools such as virtual reality (VR), augmented reality (AR), and mixed reality (MR) can authentically simulate real pharmacy workspaces, enabling repeated, risk-free practice opportunities. For example, VR-based aseptic compounding simulations can reproduce the physical layout and procedural workflow of cleanrooms while delivering real-time corrective feedback [27].

The integration of learning management systems (LMS) with gamification plugins facilitates automated task allocation, performance tracking, real-time assessment, and personalised analytics, thereby supporting individualised learning trajectories [1]. Cross-platform compatibility, including desktop, tablet, and mobile interfaces, extends access to context-rich training beyond conventional classroom settings [28]. A pharmacy-specific illustration is the development of VR simulations during the Coronavirus Disease 2019 (COVID-19) pandemic, where students practiced compounding procedures using adaptive technologies, maintaining engagement despite remote instruction [13]. From our analysis, these digital platforms bridge resource gaps in pharmacy training, especially in under-resourced settings, but require equity-focused design considerations to prevent digital divides and ensure inclusivity across socioeconomic and institutional boundaries.

2.6 Educational and Psychological Theoretical Foundations

The pedagogical foundation of gamification is grounded in multiple well-established educational and psychological theories. According to Self-Determination Theory (SDT), autonomy, competence, and relatedness constitute the three fundamental drivers of intrinsic motivation [29]. Gamified learning environments address these needs by promoting learner autonomy, progressive skill mastery, and collaborative engagement [30].

Constructivist learning theory posits that knowledge is actively constructed by learners within a social context and contextual framework [31]. Scenario-based simulations and role-playing exercises allow pharmacy students to co-construct clinical meaning through interaction with peers and simulated environments. Similarly, Kolb's experiential learning cycle emphasises the integration of concrete experience, reflective observation, abstract conceptualisation, and active experimentation as a comprehensive learning process [32]. In this context, gamification synthesises multiple theoretical models, applying SDT to stimulate motivation, constructivism to enhance cognitive engagement, and experiential learning to achieve synergistic educational outcomes. In pharmacy education, SDT manifests through autonomous drug selection or decision-making tasks in simulations, as demonstrated in entrepreneurship-based courses, where autonomy significantly improved self-efficacy [20]. Our analysis suggests that integrating these theoretical perspectives in pharmacy gamification provides a tailored pedagogical framework capable of addressing domain-specific challenges, such as ethical decision-making, more effectively than generalised educational applications.

3. Impact of Gamification on Pharmacy Clinical Skills Education

3.1 Enhancement of Learning Motivation and Engagement

Learning motivation is a critical determinant of both the effectiveness and durability of educational outcomes. Conventional pharmacy clinical skills courses, characterised by monotonous lectures and rigid procedural drills,

often fail to sustain student engagement [7]. In contrast, gamification enhances active participation by embedding elements of competition, collaboration, scenario-based simulation, and immediate feedback into the learning process [33].

Immersive learning environments, when combined with real-time performance tracking, can trigger immediate engagement while cultivating a sustained intrinsic drive for continuous learning [34]. Empirical study indicates that students participating in gamified pharmacy skills training exhibit markedly higher levels of motivation and engagement, with over 60% recommending the formal incorporation of such methods into the curricula [8]. These self-directed learning behaviours are strongly associated with improved knowledge consolidation and enhanced transfer of competencies across novel clinical contexts [35].

3.2 Knowledge Acquisition and Long-Term Retention

Although lecture-based approaches may facilitate rapid conceptual understanding, knowledge decay frequently occurs within weeks post-instruction [36]. Gamification mitigates this decline by embedding context-rich, iterative learning cycles that promote spaced repetition and practical application, thereby extending the retention window for targeted knowledge [37].

Cross-context transfer, the ability to apply learned knowledge across different scenarios, is a crucial marker of educational quality in pharmacy training. Evidence shows that gamified activities, such as "Choose Your Own Adventure" (CYOA) frameworks, yield higher student preference and improved knowledge test performance compared to traditional case-based learning [38]. Collectively, these findings suggest that gamification not only reinforces short-term recall but also enhances the flexible application of learned concepts, allowing learners to adapt more effectively to complex and dynamic clinical settings.

3.3 Enhancement of Clinical Reasoning and Decision-Making Skills

Clinical reasoning is a multifactorial cognitive process that integrates pharmacological knowledge, patient-specific variables, multidisciplinary considerations, and the anticipation of potential drug-drug and drug-disease interactions [19,39]. Gamified learning demonstrates strong suitability for training such higher-order cognitive functions. In a controlled study, a "Decision-Making Cards" approach significantly improved students' confidence in both diagnostic and prescribing tasks while deepening their comprehension of the reasoning process [19]. By simulating realistic, high-stakes clinical environments and providing immediate feedback on complex decisions, gamified interventions promote the acquisition of structured problem-solving strategies applicable under uncertainty or incomplete information, a common scenario in real-world clinical practice. From our perspective, this cognitive enhancement is vital in pharmacy, as it mitigates medication errors in ambiguous cases, offering greater translational value than purely theoretical instruction.

3.4 Strengthening Teamwork and Interprofessional Communication

Contemporary pharmacy practice emphasises interprofessional collaboration across domains such as disease management, multicentre clinical research, and policy development for multidisciplinary drug use. These collaborative efforts demand precise communication and seamless coordination among professionals from diverse disciplinary backgrounds.

Gamified instructional activities, such as role-based assignments, team competitions, and collaborative simulations, enable pharmacy students to navigate the complexities of team dynamics within a structured, low-risk environment [40]. For example, in a simulated Medication Therapy Management (MTM) program, participants assigned as pharmacists, physicians, or patients collaboratively analysed data, formulated treatment plans, and implemented interventions [23]. Evidence from interprofessional education research indicates that students exposed to gamified modules report significant improvements in perceived competence for "interprofessional teamwork" and "interprofessional communication" [41]. These findings suggest that gamification functions not only as an effective pedagogical tool for skills training but also as a valuable mechanism for fostering a culture of interdisciplinary communication. We contend that this strengthening is essential for the pharmacy's role within multidisciplinary teams, promoting safer and more coordinated patient care than isolated training approaches.

4. Challenges and Limitations

4.1 Insufficient Teaching Resources and Technical Infrastructure

High-quality gamified learning requires access to a context-specific case repository, stable and scalable digital platforms, and dedicated technical support. In practice, the development and maintenance of such infrastructure are often limited by financial and human resource constraints [23]. Many institutions lack the capacity to create customised, pharmacy-oriented gamification modules, relying instead on generic medical simulation tools that inadequately reflect pharmaceutical practice. Furthermore, evaluation protocols frequently depend on subjective learner feedback, lacking standardised implementation frameworks to ensure comparability and validity across settings [5]. From a technological perspective, limited network bandwidth and inadequate device performance can compromise the continuity and immersion of the learning experience. These technical and resource challenges are particularly severe in economically under-resourced regions, where they impede widespread gami-

fication adoption. Similarly, in pharmacy courses, especially in resource-poor areas, the availability of virtual reality (VR) and other computer simulation platforms remains uneven, which may hinder their widespread adoption and reduce the consistency of clinical skills training [42]. Based on our synthesis, this insufficiency deepens global disparities in pharmacy education, where under-resourced settings fail to benefit from gamification's potential to standardise learning, unlike more resource-rich medical disciplines.

4.2 Limited Instructor Expertise and Design Experience

Compared with conventional lectures, gamified instruction demands distinct competencies, including scenario design, mastery of digital tools, and dynamic facilitation skills. Although pharmacy educators often have deep subject-matter expertise, many lack formal training in gamification pedagogy or educational technology, limiting their capacity to design and implement robust game-based interventions [43]. This gap underscores the need for structured faculty development programs and multidisciplinary collaboration to support effective integration into pharmacy curricula. For example, a survey revealed that 65% of pharmacy faculty reported inadequate expertise in gamified tools, resulting in suboptimal implementation and reduced student performance in experiential learning [43].

4.3 Inadequate Evaluation Systems

Evaluation of gamified learning should capture multiple dimensions, including knowledge acquisition, technical proficiency, motivation, adaptability, collaboration, and critical thinking. However, many current pharmacy education programs still rely primarily on written tests or isolated performance assessments that fail to capture holistic competency development [5]. Even when learning improvements are observed, assessment validity and reliability are rarely verified, and learner satisfaction is often used as a surrogate indicator of success [6,13]. The absence of standardised, evidence-based, multidimensional evaluation tools remains a critical gap. For example, in pharmacy gamification research, reporting quality is often inconsistent, with misalignment between intended learning outcomes and outcomes reported, and an overreliance on student perceptions rather than robust objective measures. This limits the strength and comparability of the available evidence [5]. From our perspective, this methodological limitation impedes pharmacy's evidence-based advancement, as robust evaluations are essential to validate the contribution of gamification in reducing clinical errors, an impact that cannot be inferred from subjective metrics alone.

4.4 Potential Learning Objective Drift and Over-Gamification Risks

When the entertainment value of gamification overshadows its pedagogical purpose, learners may become more focused on "winning the game" than on achieving intended competencies. This risk is especially evident in highly competitive settings, where some participants adopt short-term, point-maximising behaviours that undermine deep and sustained learning [25,44]. To mitigate this, game design should ensure that engagement mechanisms reinforce, rather than replace, pedagogical rigour. For example, in leaderboard-based pharmacy games, excessive competition reduced deep learning by approximately 20% in some cohorts, as students prioritised scores over clinical accuracy [25]. We argue that in pharmacy, mitigating this risk through balanced and goal-oriented design is paramount, as objective drift may compromise ethical standards in patient-care training, distinguishing it from recreational gamification applications.

5. Practical Strategies and Recommendations

5.1 Alignment of Course Objectives With Systematic Design

The success of gamification in pharmacy education depends on precise alignment between learning objectives and game components. Clinical skills curricula typically encompass diverse competencies, including prescription review, compounding, medication counselling, and decision-making under uncertainty. Each learning objective should be translated into quantifiable, context-specific tasks, while the instructional sequence follows a goal-process-evaluation feedback cycle [45,46]. This alignment minimises entertainment drift and ensures that enjoyment complements rather than competes with learning outcomes. For example, the "International Pharmacy Game" (GIMMICS), implemented across seven universities, aligned objectives with real-world tasks such as dispensing and patient counselling, leading to enhanced diagnostic accuracy and positive student outcomes, such as enhanced clinical competence and recommendations for curriculum integration [47]. Based on our synthesis, such alignment is especially effective in pharmacy education, as it mirrors regulatory standards and fosters authentic clinical practice more directly than abstract educational approaches.

5.2 Instructor Training and Interprofessional Support Teams

Instructors are the primary agents in successful gamification implementation [48]. Targeted professional development should include scenario design, platform operation, interaction facilitation, and formative assessment methodologies. Establishing interprofessional support teams, comprising pharmacy educators, instructional technologists, software engineers, and simulation specialists, can facilitate the co-creation of high-quality, scalable gamification modules [49]. Additionally, the creation of online training resources, including standardised templates, reusable case libraries, and interactive simulation exercises, can help instructors to refine their teaching approaches continuously and maintain up-to-date pedagogical practices. A

pharmacy-specific faculty training initiative demonstrated that 80% of participants reported increased confidence in using gamified instructions, accompanied by improved student engagement [43].

5.3 Technological Platforms and Resource Development

A reliable and adaptable platform is a prerequisite for sustainable gamification. Pharmacy schools may either integrate gamification plugins into existing learning management systems or develop specialised platforms capable of automated grading, real-time performance analytics, and adaptive task allocation. Immersive technologies such as VR and AR can accurately simulate critical practice environments, including aseptic compounding units, hospital pharmacies, and ward-based consultations, allowing repeated, risk-free skill rehearsal without material waste [50]. From a resource perspective, a collaborative, inter-institutional sharing model is recommended for developing national or regional pharmacy case libraries [51]. Such cooperative networks can minimise development costs, increase diversity of scenarios, and enhance assessment consistency across institutions.

5.4 Multidimensional Assessment and Personalised Feedback

Evaluation frameworks should include formative and summative components, capturing cognitive, technical, and collaborative competencies. Assessment tools may include system-logged task performance metrics, peer review scores, reflective journaling, and integrated clinical scenario assessments. Learning analytics dashboards further enable instructors to deliver personalised, data-driven feedback by identifying gaps in knowledge structures, decision-making logic, or technical execution [52,53]. This approach supports targeted remediation and facilitates skill progression. In a gamified pharmacy training initiative, the use of learning analytics-based multidimensional assessment improved participant satisfaction and motivation [8].

5.5 Step-By-Step Implementation Framework

To provide a structured roadmap for pharmacy programs, we propose the following step-by-step framework for implementing gamified learning (Fig. 1). This framework integrates the strategies discussed above and aligns with pharmacy-specific needs such as patient safety, clinical accuracy, and regulatory compliance. It begins with a comprehensive needs assessment, followed by systematic design, pilot testing and iterative evaluation to address challenges such as limited resources and technical constraints (Fig. 1).

6. Ethical and Equity Considerations

6.1 Data and Privacy Protection

Gamified pharmacy training, particularly those involving virtual patients, may require the integration of real or partially anonymised patient data. All case materials should therefore undergo full anonymisation, and robust encryption protocols must be applied both during storage and transmission [54]. Additionally, all participants and instructors should receive formal training in privacy compliance to minimise risks of information breaches. Based on our synthesis, prioritising data protection within pharmacy gamification not only mitigates legal and ethical risks but also builds institutional and learner trust in digital tools, an essential factor when handling real-world patient data, unlike less sensitive educational fields.

6.2 Equity and the Digital Divide

While digital gamification offers considerable learning benefits, it may inadvertently widen educational inequities by favouring learners with better access to reliable internet connections and modern devices. Technical barriers such as hardware shortages, network latency, and platform incompatibility are particularly evident in resource-limited settings [55]. Mitigation strategies include implementing low-cost device loan programs, designing low-bandwidth-compatible platforms, and adopting blended offline-online delivery models to ensure inclusive access regardless of socioeconomic background. In our analysis, addressing the digital divide is a moral and pedagogical imperative for pharmacy, ensuring equitable training opportunities for diverse populations and preventing the deepening of healthcare disparities in underserved regions.

To illustrate ethical and equity considerations in gamified pharmacy education, we suggest the inclusion of a summary table outlining a balanced ethical-equity framework (Table 1).

7. Discussion

This review confirms that gamification is not merely an emerging pedagogical trend but a progressively validated instructional strategy for enhancing learner motivation and developing core competencies in pharmacy clinical skills education. While its benefits are well-documented in medical and other health science domains, accumulating evidence now supports its applicability and efficacy within pharmacy-specific curricula [52]. The reviewed literature indicates that deliberately structured gamified interventions can elevate learner engagement, strengthen long-term knowledge retention, and narrow the persistent theory-practice gap in clinical training [50].

Despite these promising results, the widespread and sustainable adoption of gamification remains constrained by interconnected barriers, including resource limitations, technological constraints, insufficient instructional design expertise among faculty, and a lack of standardised evaluation models [56]. These findings underscore the need for strategic, incremental integration, beginning with targeted pilot programs within selected courses or skill modules, followed by data-driven expansion based on empirical

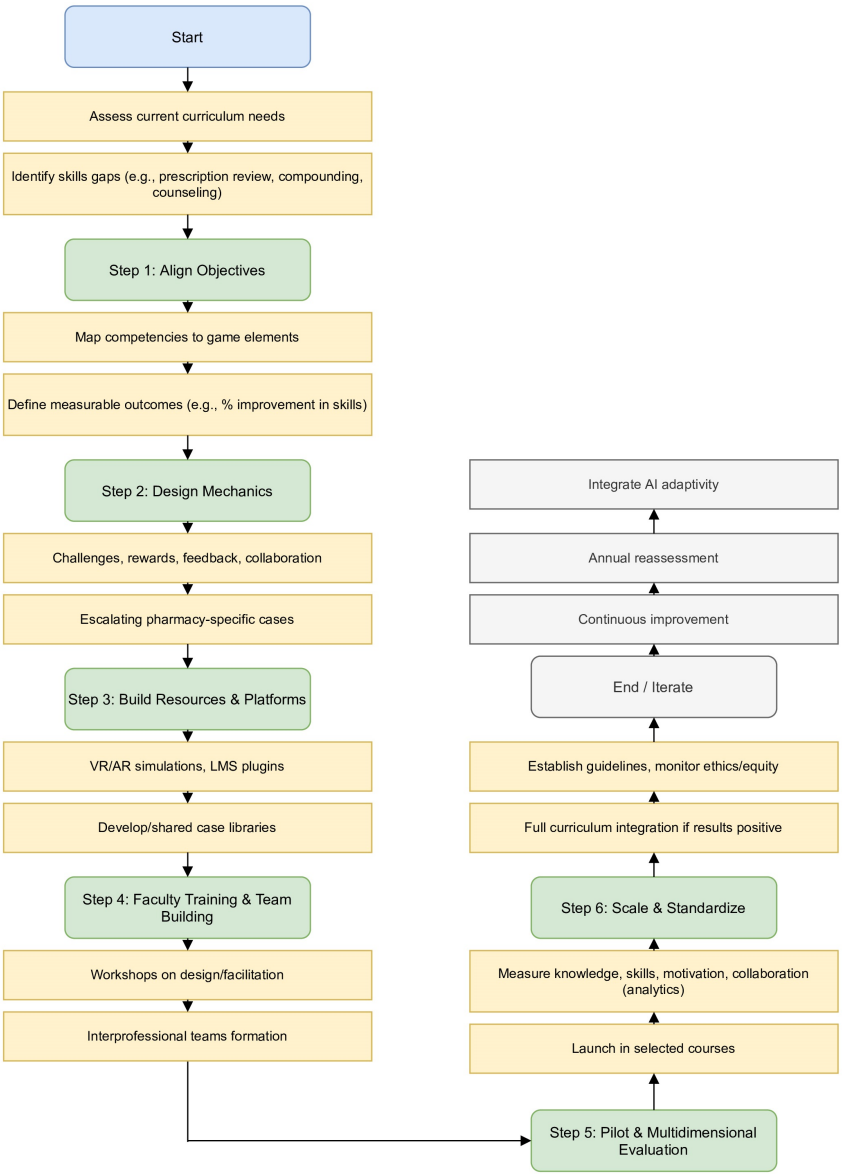

Fig. 1. Implementation framework for gamified learning in pharmacy clinical skills education. VR, virtual reality; AR, augmented reality; LMS, learning management systems; AI, artificial intelligence.

outcomes. Furthermore, an interdisciplinary development model, uniting pharmacy educators, educational technologists, healthcare practitioners, and simulation developers, should be prioritised to optimise design quality and cost-effectiveness. Cross-institutional sharing of scenarios and evaluation tools can further reduce redundancy, foster consistency, and accelerate the establishment of standardised best practices.

The integration of AI-driven adaptive learning systems with gamification offers especially promising future directions. By dynamically adjusting task complexity and content sequencing based on learner analytics, AI systems can deliver personalised, competency-targeted training pathways. Moreover, longitudinal studies linking gamified learning outcomes with real-world clinical performance metrics, such as prescription accuracy, medication error prevention, and patient satisfaction, will be essential for determining true translational impact. To advance this field, we recommend: (1) conducting multicentre randomized controlled trials (RCTs) within pharmacy programs to compare AI-enhanced gamification with traditional modules, focusing on long-term clinical outcomes (e.g., error reduction rates from 3-month pilot studies across 5–10 institutions); (2) developing adaptive AI frameworks through iterative design, beta testing, and scaled deployment cycles informed by learner feedback; and (3) establishing pharmacy-specific, evidence-based standards through consensus by professional bodies (e.g., American Association of Colleges of Pharmacy), emphasising measurable indicators of equity and efficacy [54].

Table 1. Framework for ethical and equity considerations in gamified pharmacy education.

Aspect	Key challenges	Recommended strategies	Pharmacy-specific implications
Data privacy	Risk of breaches involving virtual patient data	Implement full anonymisation, encryption, routine security audits, and targeted privacy compliance training	Minimises errors in pharmacogenomic simulations and ensures compliance with pharmaceutical data protection and regulatory standards
Digital equity	Access barriers in resource-limited learning environments	Establish device loan programs, design low-bandwidth-compatible platforms, and adopt blended online-offline instructional models	Promotes inclusive, competency-based training for pharmacists globally and mitigates rural-urban disparities in clinical skills acquisition
Ethical oversight	Potential bias and fairness concerns in AI-driven gamified systems	Conduct regular ethical edits, employ inclusive and culturally sensitive design principles	Prevents inequitable learning outcomes in simulated medication counselling and strengthens fairness in interprofessional collaboration

From our perspective, these targeted approaches will advance pharmacy education toward a more evidence-based, data-responsive, and equitable model, capable of adapting to the rapid evolution of pharmaceutical innovation, unlike static pedagogical frameworks in other disciplines.

Ultimately, the future viability of gamification in pharmacy education depends not only on technological advancement but also on institutional commitment, supportive policy environment, and sustained faculty readiness. These foundational structures are essential for transitioning gamification from isolated experimental applications to mainstream, sustainable pedagogy in health professions education. We argue that in pharmacy, this viability depends on aligning gamification with broader global health priorities, such as equitable access to high-quality training, to maximise its contribution to patient safety, professional competence, and the continuous evolution in pharmacy practice.

8. Conclusion

As an innovative model integrating pedagogy, psychology, and modern information technology, gamification offers a novel approach for pharmacy clinical skills education. It not only significantly enhances student motivation and engagement but also effectively supports long-term knowledge retention, skill transfer, clinical reasoning, and teamwork development. Compared with traditional lecture-based instruction, gamification provides an immersive, multidimensional, and sustained learning experience that bridges the gap between theoretical understanding and clinical application.

However, sustainable and equitable adoption will require addressing several interrelated challenges: ensuring alignment between game mechanics and competency-based objectives, providing comprehensive instructor training, investing in scalable technological infrastructures, and developing robust multidimensional evaluation frameworks. Ethical safeguards, including data privacy protection and equitable access across the digital divide, must also be integrated into any large-scale implementation strategy to mitigate unintended inequities.

In conclusion, evidence-based, standardised, and systematically designed approaches are critical for advancing gamification in pharmacy education. With continued policy support, technological advancement, and evolving educational paradigms, gamification has the potential to become an integral component of pharmacy clinical skills training, substantially contributing to the development of competent, patient-centred pharmacists and advancing public health outcomes. We argue that realising this potential requires pharmacy-specific innovations, such as AI-enhanced adaptive learning systems, to align with global competency standards established by organisations like the International Pharmaceutical Federation, ensuring long-term impact on public health.

Key Points

- Gamification integrates game mechanics into pharmacy clinical skills education, significantly enhancing learner motivation, knowledge retention, clinical reasoning, and interprofessional collaboration through immersive simulations tailored to real-world scenarios, such as prescription review and medication counselling.
- Compared with traditional didactic approaches, gamified interventions address deficiencies such as low engagement and limited skill transfer, with empirical evidence showing improvements in competency metrics by 15–30% in pharmacy-specific training settings.
- Key challenges include resource limitations, gaps in faculty expertise, inadequate evaluation frameworks, and ethical issues such as data privacy and digital inequity, which must be mitigated through systematic alignment, faculty training, and inclusive platform design.
- Practical strategies involve the use of interprofessional design teams, scalable technologies (e.g., VR/AR), and

multidimensional assessment models supported by personalised, analytics-driven feedback, ensuring sustainable integration across diverse educational settings.

- Future research priorities include AI-driven adaptive gamification, longitudinal studies linking gamified learning to clinical outcomes (e.g., prescription error reduction), and the development of standardised evaluation guidelines via professional pharmacy education bodies.
- Ultimately, the mainstream integration of gamification in pharmacy education depends on institutional commitment, policy support, and faculty readiness, positioning it as a vital tool for enhancing pharmacist competence and improving patient-centred healthcare delivery.

Availability of Data and Materials

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions

BH and NWZ designed the research study. BH and YLZ performed the research. BH drafted the manuscript. All authors contributed to the important editorial changes in the manuscript. All authors read and approved the final manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

Not applicable.

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Conflict of Interest

The authors declare no conflict of interest.

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