

# Using Gamification to Improve Medical Student Education: An Emphasis on Anatomy, Pathology, and Pharmacology

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**ABSTRACT**

Traditionally, medical training utilized rote memorization strategies, didactic lectures, and dissections of cadaveric donors to convey information. As significant as these traditional methodologies have been in shaping medical training, they often fail to maintain student engagement and do not always foster the deep conceptual understanding necessary for clinical proficiency. Given the high cognitive loads experienced by medical students, new methodologies that maximize motivation, recall, and hands-on practice are increasingly researched. Gamification, defined as the integration of game elements such as points, levels, rewards, leaderboards, and interactive simulations, has gained traction as an effective educational tool.

This article addresses the use of gamification in medical education, namely in pathology, anatomy, and pharmacology. Empirical studies are utilized to examine how educational tools with a gamified format enhance motivation, problem-solving, and the application of information. Key advantages include increased student engagement, improved recall, and a more interactive approach to medical training. However, challenges such as cognitive overload, varied student preferences, and resource constraints are also analyzed. By evaluating the effectiveness and limitations of gamification, this paper contributes to a growing discourse on innovative educational strategies that can improve medical training, with the goal of better preparing students for clinical practice.



**KEYWORDS**

Gamification, Medical Education, Anatomy, Pathology, Pharmacology

## 1 | INTRODUCTION

Traditionally, medical training involved didactic lectures, dissection of cadaveric donors, and immense levels of memorization to impart information. As beneficial as these approaches have proven in shaping medical training, in many instances, they have struggled to maintain students' motivation. (1) Additionally, modern learning environments introduce new challenges to sustained attention, including the widespread use of mobile phones, social media, and increased multitasking, which may contribute to reduced concentration and engagement during traditional lecture-based instruction. (2) In addition, developing a deep understanding of many complex concepts required for effective practice in the medical field remains a challenge. (1) Medical training, with its lengthy years of study, high cognitive demands, and many high-stakes examinations, can lead to high levels of burnout and stress among students. (1) Burnout can have repercussions in terms of poor academic performance, poor recall of information, and mental health struggles. Therefore, there is a strong need for more engaging, motivating, and innovative learning methods within the medical curriculum. (3)

In recent years, the integration of gamification—defined as the application of game design elements in non-game contexts—has emerged as a novel approach to enrich learning experiences in medical education. (4) Gamification leverages elements such as points, badges, leaderboards, and interactive challenges to create an engaging learning environment. The underlying theoretical model, namely, self-determination theory, allows for the student's motivation to arise from three general psychological needs: autonomy, competence, and relatedness. (4) By employing such gaming strategies, educational interventions can maximize intrinsic motivation and, in consequence, learner achievement and engagement. Earlier digital learning tools, including spaced-repetition platforms such as Anki, rapid slide-based quizzes, and interactive polling during lectures, were already used to encourage engagement and reinforce recall. These approaches have been widely studied as effective

methods for enhancing active learning and knowledge retention in medical education. (4) Approaches such as competition boards, interactive challenges, point schemes, and immediate feedback have been used to stimulate motivation and improve recall. Over time, some of these have become new models for enriching medical school education. (3) Studies have shown that gamified learning environments can improve participation, foster a sense of achievement, and make complex medical subjects more accessible and enjoyable. (4) All these benefits can be most useful in courses such as pharmacology, pathology, and anatomy, where students must memorize and apply large volumes of information.

Beyond improving engagement, gamification aligns with active learning principles, promoting problem-solving, critical thinking, and collaboration, which are essential skills for future healthcare professionals. (5) In addition, by simulating real-life scenarios, gamification can allow learners to practice in a safe environment where mistakes can occur without risk to patient safety. These platforms can also provide immediate feedback and opportunities for repeated practice, helping students improve their clinical reasoning while incorporating elements of peer competition and still emphasizing mastery of core competencies. This has the potential to bridge the gap between theory and practice. (6) Gamified platforms may also support distance and remote learning environments that became more common following the SARS-CoV-2 pandemic, allowing interactive participation even when traditional in-person instruction is limited and helping facilitate engagement in larger class settings.

In this article, the efficacy of gamification in medical student training in anatomy, pathology, and pharmacology is evaluated, with consideration of both its advantages and limitations. By comparing and contrasting the effectiveness of gamification on student motivation, recall, and academic performance, this discussion aims to shed light on its role in medical training as a potentially revolutionary educational tool.

## 2 | GAMIFICATION IN ANATOMY EDUCATION

Anatomy is a core part of medical curricula, offering key information about the structure and function of the human body. Nevertheless, its complexity, information overload, and the conventional use of cadaveric dissection can pose challenges to students' motivation, understanding, and information recall. Many students have difficulty in perceiving three-dimensional structures and understanding their spatial relationships, which are essential for clinical application. (7) To counteract such obstacles, instructors have designed gaming tools that create interactive, immersive educational environments, enhancing both effectiveness and motivation in studying anatomical concepts.

One of the most successful gamified approaches in anatomy training is the use of interactive, highly detailed virtual three-dimensional dissection platforms for simulation and research. These platforms allow students to explore anatomical structures in a simulated environment, promoting spatial understanding and long-term retention. (7) Unlike two-dimensional representations in textbooks or conventional cadaver dissection, virtual tools enable learners to manipulate structures, rotate them, and visualize cross-sectional structures dynamically, thereby facilitating hands-on learning. These digital resources are also more accessible and cost-effective than maintaining cadaver laboratories, making them an attractive alternative or supplement for anatomy education. Virtual anatomy platforms and interactive dissection tools have increasingly been adopted in medical education to support spatial learning and student engagement, and similar technologies have been incorporated across medical education settings. (8)

Moro et al. (2017) conducted a comparative analysis between augmented reality (AR), virtual reality (VR), and traditional methods in studying anatomy. (8) In terms of increased knowledge, the analysis found that all three methods were effective; however, students using AR and VR exhibited higher motivation, engagement, and overall satisfaction. The immersive nature of AR and VR technologies enables learners to experience anatomy

in ways that more closely mimic real-life clinical scenarios, facilitating the application of theoretical knowledge. Gamification elements such as quizzes, progress tracking, and interactive challenges embedded within these platforms further reinforce learning. For example, students may complete short quiz rounds that award points or badges for correct responses, track their advancement through levels or achievement dashboards as modules are completed, or participate in timed leaderboard challenges that encourage repeated practice and friendly competition among peers. (4)

Apart from AR and VR, gamification in anatomy education can extend to mobile applications and simulation-based games that incorporate competition, rewards, and adaptive study pathways. All such tools enable students to study independently, be given immediate feedback, and engage in personalized study routines, thus leading to a deeper level of complex understanding. For example, case-based approaches allow students to use their anatomical knowledge to bridge the gap between theoretical learning and clinical application. (5)

In general, the use of gamification in anatomical education has significant potential to increase motivation, comprehension, and long-term recall among students. While traditional methodologies will always have a role, gamified tools can serve as strong adjuncts, particularly in overcoming barriers to visualization, interactivity, and motivation.

## 3 | GAMIFICATION IN PATHOLOGY EDUCATION

Pathology, the study of disease mechanisms and histological patterns, is a critical component of medical education. Traditional pathology training often involves passive study techniques, such as lectures and slide-based review of histological specimens, often presented through PowerPoint discussions or microscopic demonstrations. These methods may not actively engage students, making it difficult to develop the critical thinking skills associated with these topics. Gamified learning activities, in contrast, require learners to apply knowl-

edge through problem-solving tasks, interactive quizzes, or case-based challenges that promote analytical reasoning, improve information recall, and encourage discussion and collaboration among learners. (4) To address these challenges, educators can turn to gamification techniques to create more interactive and stimulating learning experiences.

A particularly striking example is the use of gamification in histopathology training. In a study conducted at Paracelsus Medical University in Salzburg, Austria, Kahoot! was implemented in real-time examination in (histo-)pathology lecture environments. (9) Student performance exhibited a considerable improvement in correct answer proportion—from a mean of 47.2% at baseline to 77.2% post-lecture. There was also a 50% reduction in answer times, indicative of increased efficiency in studying. Student feedback exhibited high acceptance of this gamified format, highlighting its effectiveness in improving learning outcomes in anatomical pathology and morphological topics.

A new and emerging direction in pathology education is the integration of game-based assessments that combine simulation and gamification. Such approaches can enhance pathology education, including student engagement and interest in the subject. As discussed by Shrivastava et al. (2024), such assessments have much potential in enhancing critical thinking and decision-making skills in medical students. (10) Despite discussing the challenges of integration, the authors advocate for a systematic approach to seamlessly integrate these assessments into medical curricula. These approaches may also help prepare students for clinical training and residency by strengthening diagnostic reasoning, decision-making under pressure, and collaborative problem-solving. (10)

The application of VR in pathology training has also been researched to enable immersive learning experiences. For example, Huber et al. (2022) developed a transfusion service laboratory in a VR environment to educate students on immunohematology subjects. (11) The use of educational materials in a virtual laboratory with a gaming environment was effective in engaging students and clarifying complex topics.

Overall, the use of gamification in pathology training can make learning fascinating while also encouraging active participation, critical thinking, and information recall. By transforming traditional passive training methodologies into immersive, participatory experiences, gamified approaches can better prepare medical students for practice in a clinical environment. As technology continues to develop rapidly, new and exciting opportunities for gamification in pathology training will emerge, enhancing students' competency and learning.

## 4 | GAMIFICATION IN PHARMACOLOGY EDUCATION

Pharmacology, encompassing the study of drug mechanisms, therapeutic applications, and adverse effects, presents a complex and extensive subject matter that many medical students find challenging. To make pharmacology instruction more manageable, instructors have considered numerous approaches to gamify teaching sessions to promote active learning and maximize recall. A quantitative systematic review in 2023 by Hope et al. examined the application of gamification in pharmacology education. (12) The study analyzed 66 articles describing gamified interventions across 12 countries, involving over 8,000 students. The gamified approaches ranged from board games to immersive simulations, with escape rooms being the most frequently reported. The review highlighted the need for improved research quality and better alignment of learning outcomes with these evaluation methods.

In another study, Oestreich and Guy (2022) discussed the role of game-based learning (GBL) in pharmacology education. (13) They noted that GBL, which involves incorporating game elements into non-game activities, can effectively engage students and enhance learning outcomes. GBL was described as leading to long-term student engagement and information recall. The authors also noted the need for more clearly defined assessment methods to evaluate the effectiveness of GBL activities.

Moreover, the review by Hope et al. (2023) further

analyzed the use of gamification in the context of pharmacology. (12) The findings suggested that gamification, when effectively implemented, can enhance student engagement and learning outcomes in pharmacology. However, the study also emphasized the need for rigorous research to establish best practices and ensure that gamified interventions are pedagogically sound and aligned with educational objectives.

## 5 | CHALLENGES AND CONSIDERATIONS IN IMPLEMENTING GAMIFICATION

While the benefits of gamification in medical education are evident and well-studied, several challenges and considerations must be addressed to ensure its effective implementation. Cognitive overload is one such issue and incorporating gaming elements can distract learners from educational content. De-Marcos et al. (2014) stressed that poorly designed gamified interventions can result in a dip in learning performance through increased cognitive load. (14)

An additional consideration is variation in learner preferences and learning styles. Not all students will necessarily enjoy gamified strategies nor respond effectively to them. Hamari et al. (2016) showed that individual variation, including personality and gaming background, can have an impact on effectiveness of gamification. (2)

Also, the development and deployment of gamified tools require significant investments in funding, time, and technical expertise. Wang et al. (2016) supplemented that successful gamified learning experiences demand significant collaboration between subject matter experts and game designers, which can be resource-intensive. (5)

Competition in specific gamified dimensions can also make learners stressed and nervous, and subsequently, can affect their performance and motivation in a negative manner. In a study conducted by Lester et al. (2023), competition can motivate a group of students but can also have a negative effect, causing them to participate

less and perform worse if the circumstances are not optimized. (15)

Moreover, integrating gamification into existing curricula poses logistical challenges. Tabassum (2024) identified issues such as aligning game mechanics with learning objectives, ensuring accessibility for all students, and providing educators with adequate training to effectively facilitate gamified activities. (16)

Despite its potential, careful consideration must be given to such challenges in the context of medical educational gamification. Tailoring gamified interventions to diverse learner needs, ensuring thoughtful design to prevent cognitive overload, and allocating appropriate resources for development and implementation are crucial steps toward successful integration.

## 6 | FUTURE DIRECTIONS AND RECOMMENDATIONS

The integration of gamification into medical education is an evolving field with significant growth potential. Future studies will need to assess the long-term effectiveness of gamified interventions both in terms of academic performance and their impact on learning in clinical settings. There is a need for uniform frameworks to guide the development and assessment of gamified tools, ensuring consistency and rigour across studies.

Educators are encouraged to adopt a learner-centred approach when implementing gamification, involving students in the development process to better tailor interventions to their needs and preferences. Institutions may also collaborate with technology developers to create high-quality, evidence-based, and objectives-mapped gamified educational tools. Funding opportunities and institutional grants may further support the development of gamification tools in education. Pilot initiatives exploring gamified learning strategies are beginning to emerge in medical education programs, including within Canadian institutions. (4)

## 7 | CONCLUSION

Gamification has the potential to revolutionize medical training by making learning more engaging, interactive, and effective. In anatomy, pathology, and pharmacology, gamified tools have demonstrated their ability to enhance knowledge retention, critical thinking, and practical application. While challenges exist, strategic implementation and ongoing research can maximize the benefits of gamification, ultimately contributing to the development of competent and motivated medical professionals.

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