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Exploring the Practical Application of Gamified Incentive Mechanisms in Pathology Teaching

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Abstract

In response to the problems such as low participation and insufficient practical training of students in traditional laboratory teaching, this study aims to explore the effectiveness and feasibility of the gamified incentive mechanism (GIM) in this field. 84 undergraduate students majoring in clinical medicine were randomly divided into the experimental group ($n = 42$) and the control group ($n = 42$). The control group received traditional conventional teaching, while the experimental group adopted the self-developed GIMM model (derived from the TPR model), and designed specific game incentive mechanisms, such as point systems, leaderboards, reward mechanisms, etc. The teaching content, time arrangement, and assessment criteria of both groups were kept consistent. The teaching effectiveness was evaluated through knowledge assessment, learning satisfaction survey, and teaching satisfaction survey. Statistical analysis was conducted using SPSS 29.0. The results showed that the total knowledge score of experimental group achieved a significantly higher (85.31±8.81) than that in the control group (79.36 ± 6.47) ($P < 0.05$), with notable advantages in single-choice questions, specimen identification, and pathological section interpretation ($P < 0.05$ or $P < 0.01$). The experimental group also demonstrated higher satisfaction rates in learning interest (90.48%), classroom engagement (88.10%), and clinical thinking training (95.24%) ($P < 0.05$). The research conclusion indicates that integrating GIM into the teaching of pathology has significantly improved the teaching effectiveness and student satisfaction, addressing long-standing issues such as low participation and insufficient practical training. It has enhanced their academic performance and practical abilities. With the further popularization of digital technology in medical education, game-based teaching is expected to provide a highly promising improvement method for optimizing pathology education.

Keywords

Gamified Incentive Mechanism, Pathology Teaching, Experimental Teaching, TPR Model, Medical Education

1. Introduction

By CNNIC on July 21, 2025, the number of netusers has reached 1.123 billion in China, with an internet availability rate of 79.7%, Ranked first globally, according to the 56th Statistical Report on Internet Development in China [1]. What makes online games so appealing to adolescents and even adults? Research suggests that several psychological dimensions—including competition, meeting challenges, mood enhancement, escapism, fantasy, skill development, entertainment, and social interaction—contribute to the attractiveness of games [2] [3]. Elements such as purchasable loot, novel rewards, realistic graphics, role-playing functions, and achievement systems in the game can provide players with an immersive experience, but also lead to varying degrees of out-of-control situations or even addiction [3].

Since the 1980s, the motivational mechanisms underlying online games have attracted scholarly attention, prompting attempts to apply them in education to stimulate learner engagement and integrate gaming elements into teaching [4]. As a core component of games that fosters interest, the Gamified Incentive Mechanism (GIM) encourages participation, promotes engagement, and sustains continued activity. Based on the psychological needs and behavioral patterns of players, GIM facilitates exploratory learning through game-like interactions by providing continuous positive feedback and through interactive means similar to those in games [5].

The "Target-Process-Reward" (TPR) model, based on the GIM, is a systematic structure consisting of three core elements, established based on GIM. Its includes: ① Target: Refers to hierarchical learning goals set in combination with learners' basic competencies, encompassing both short-term goals such as mastering foundational knowledge points and long-term goals including the cultivation of practical skills and clinical thinking. The target has the characteristics of clarity, achievability, and challenge; ② Process: Denotes the learning implementation phase that connects targets and rewards, emphasizing collaborative and feedback-based learning scenarios designed according to the target tasks, and focusing on the learners' experience and ability improvement during the participation process; ③ Reward: This refers to the diversified incentive system based on learning performance and participation in the process, including material rewards, honor recognition, and opportunities for ability improvement. It aims to strengthen learning motivation and sustain learning continuity through positive feedback. In recent years, this TPR Model has been increasingly widely applied in the innovation of medical and nursing education [6]. For instance, Juan Pimentel *et al.* jointly designed an educational game prototype that included 268 medical students from Columbia University, incorporating game dynamics, scenarios, learning goals, and instructional strategies, thereby promoting the application of gamification in medical education [7].

Pathology is a compulsory course that connects basic sciences with clinical practice in traditional medical education. It provides medical students with necessary diagnostic reasoning skills and clinical insight, emphasizing a deep understanding of disease mechanisms. However, the traditional teaching methods often place more emphasis on theoretical knowledge and neglect practical skills and case-based analysis [8]. Pathology intersects closely with clinical medicine, medical imaging, and diagnostics. However, students often lack the ability for interdisciplinary collaboration and comprehensive analysis [9]. This study introduces the TPR model into multimedia digital pathology laboratory platform to evaluate the effectiveness and feasibility of GIM in pathology experimental teaching.

2. Materials and Methods

2.1. Participants and Grouping

84 undergraduate students majoring in clinical medicine were enrolled. By the end of preceding three semesters, all participants had completed the basic medical courses, with comparable academic performance and experimental scores. The baseline academic performance (average score of the experimental group: 78.2 ± 4.5 points; average score of the control group: 77.8 ± 4.8 points) and the experimental assessment scores (average score of the experimental group: 80.1 ± 3.9 points; average score of the control group: 79.7 ± 4.2 points) were comparable. The P values for inter-group comparisons were 0.682 and 0.715 (both $P > 0.05$). The recruiters were randomly divided into the experimental group ($n = 42$) and the control group ($n = 42$). Each group was further divided into 7 study teams, with each team consisting of 5 to 7 students. Each team included at least 2 to 3 female to balance the gender ratio. The study has been approved by the Teaching Management Committee of the School of Medicine at Yangtze University. The chapter on respiratory system diseases in the pathology textbook (People's Medical Publishing House) was selected as the teaching content. Instruction was conducted in two virtual digital multimedia pathology laboratories equipped with optical microscopes.

2.2. Construction of the GIMM Model

Building on the 19 core categories of the traditional TPR model [10] [11] and considering pathology teaching characteristics, the GIMM model was developed around three pillars:

Task Design: Twenty typical electronic medical records, jointly reviewed by respiratory clinicians and pathologists, were selected. These covered conditions such as chronic bronchitis, pneumonia, and lung cancer, and included complete medical histories, imaging data, and digital pathological sections (with diagnoses concealed). Tasks were categorized into five difficulty levels (A - E).

Point and Ranking System: Knowledge points were quantitatively scored, with weights assigned based on task difficulty and importance. A hybrid scoring model incorporating both team collaboration and individual contribution was implemented. Effective ideas proposed by individuals and adopted by the team earned extra points for both the individual and the team. Additional rewards were granted for sustained learning (e.g., one-hour continuous study) to encourage extended self-directed learning. No failure mechanism was imposed; students could retry tasks until completion.

Multi-Dimensional Reward System:

① Credit Rewards: Be used to redeem course grades or internal assistance services.

② Honorary Rewards: Virtual medals will be awarded to the teams with top-performing and those who complete the tasks the fastest; consistently high achievers gained access to seminars with senior professors.

③ Substantive Rewards: Top three teams were offered internship opportunities in the pathology and respiratory departments of the affiliated hospital; the first-place team member received a pathology atlas.

④ Dynamic Adjustment: Regular feedback was collected to calibrate task difficulty and reward criteria, ensuring fairness and sustained engagement.

2.3. Teaching Implementation

Control Group: Teachers mainly conducted one-way knowledge transmission, systematically explaining the pathological mechanism, morphological characteristics and diagnostic key points of respiratory system diseases. Subsequently, they demonstrate pathological section images of typical cases through digital slices, and laboratory observation of pathological organ specimens and microscopic slides was also conducted. After class, experimental reports based on their observation results and class notes were submitted. Teachers provided centralized feedback through grading the reports.

Experimental Group: Accessed hierarchical medical record tasks, digital specimens, and section resources. Groups progressed sequentially through Levels A - E. Upon report review and reward distribution, the subsequent level was unlocked. Uncompleted tasks could be continued post-class. Instructors acted as "NPCs" (non-player characters) to provide guidance with specific responsibilities as follows:

① Clarify the learning objectives, completion standards, and scoring rules at each level, but allow students to control the learning pace independently.

② Center on cases to design interactive activities, provide diagnostic guidance when the progress is lagging, answer questions without directly giving solutions, and follow the "minimum necessary principle" in the intervention process to avoid replacing students' independent thinking.

③ Real-time track task progress and points, offer prompts or suggestions to groups with different performances, encourage full participation of all members, reward effective contributions, and link with the point/reward system.

④ Collaborate and coordinate to solve issues related to group division and disputes.

⑤ Trigger rewards and advanced resources on demand after the completion of diagnostic tasks to facilitate the development of students' professional capabilities.

2.4. Outcome Evaluation

Knowledge Assessment: A unified post-course examination was administered, comprising 40 single-choice questions, 5 terminology explanations, 3 case analyses, and 5 questions each on specimen and section identification (total score: 100). To minimize evaluator bias, subjective questions types such as case analysis and term explanation are scored using a blind evaluation method. Before scoring, students' personal identification information such as names and IDs are concealed. 2 evaluators conduct independent scoring. A third evaluator is invited to arbitrate if the difference in scores exceeds the preset threshold.

Learning Satisfaction Survey: An anonymous questionnaire survey was used to cover four aspects: perceived learning effectiveness, learning interest, self-directed learning ability, and classroom enjoyment. A 10-point Likert scale was applied (≥9 points = satisfied, 6 - 8 points = basically satisfied, ≤5 points = dissatisfied), and the satisfaction rate was calculated. This questionnaire was revised based on mature scales in the field of medical education. Verified through a pre-survey ($n = 30$), the Cronbach's α coefficient was 0.86, indicating good reliability of the scale. Content validity was verified through the expert consultation method, with an expert consistency coefficient of 0.89, ensuring the validity of the questionnaire measurement.

Teaching Satisfaction Evaluation: Covered four dimensions: content delivery, instructional organization, heuristic teaching, and clinical thinking cultivation, using the same scoring system.

2.5. Statistical Analysis

Data were analyzed using SPSS 29.0. Normally distributed continuous variables were expressed as mean ± standard deviation and compared via independent samples t-tests. Categorical data were presented as percentages and analyzed using chi-square tests. A P-value < 0.05 was considered statistically significant.

3. Results

3.1. Knowledge Assessment Scores

The experimental group outperformed the control group in total score and across key question types, including single-choice questions, specimen identification, and pathological image interpretation ($P < 0.05$ or $P < 0.01$) (**Table 1**).

Table 1. Comparison of practical ability assessment scores between the two groups (mean ± SD).

Group	*n*	SCQ	TE	CA	SI	PII	Total Score*
Control	42	28.33 ± 4.74	13.93 ± 1.60	17.93 ± 2.72	9.61 ± 0.79	9.24 ± 1.16	79.36 ± 6.47
Experimental	42	30.93 ± 6.72**	13.92 ± 1.85	20.88 ± 2.62**	9.85 ± 0.52**	9.71 ± 0.71**	85.31 ± 8.81*

Note: *P < 0.05, **P < 0.01 versus control group. SCQ = single-choice questions; TE = terminology explanations; CA = case analysis; SI = specimen identification; PII = pathological image interpretation.

3.2. Learning Satisfaction

The experimental group reported significantly higher satisfaction rates in all surveyed domains: learning effectiveness, interest, self-directed learning, and classroom enjoyment (P < 0.05 or P < 0.01) (Table 2).

Table 2. Learning satisfaction survey results (% satisfied).

Group	Control Group (n = 42)				Experimental Group (n = 42)			
	SA	BSA	DIS	SR (%)	SA	BSA	DIS	SR (%)
Learning Effect	8	14	20	52.38	20	16	6	85.71*
Learning Interest	10	13	19	54.76	30	8	4	90.48**
Independent Learning	7	12	23	45.24	24	10	8	80.95**
Classroom Fun	9	9	24	42.86	25	12	5	88.1**

Note: *P < 0.05, **P < 0.01 versus control group. SA = Satisfied; BSA = Basically Satisfied; DIS = Dissatisfied; SR= Satisfaction Rate (%).

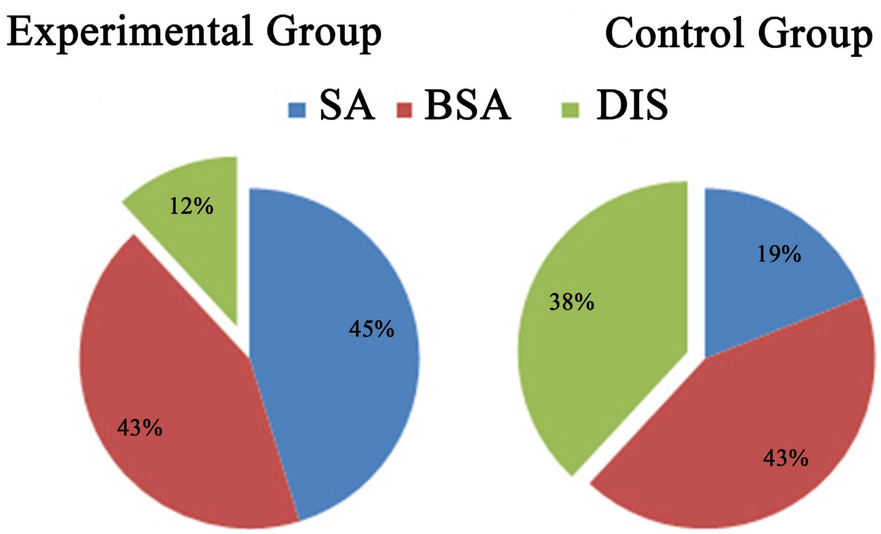
3.3. Teaching Satisfaction

Overall teaching satisfaction was markedly higher in the experimental group (P < 0.05). Satisfaction rates regarding content, organization, heuristic teaching, and clinical thinking training were all superior to those in the control group (Table 3, Figure 1).

Table 3. Teaching satisfaction evaluation (% satisfied).

Group	Control Group (n = 42)				Experimental Group (n = 42)			
	SA	BSA	DIS	SR (%)	SA	BSA	DIS	SR (%)
Teaching Content	13	18	11	73.81	22	17	3	92.86**
Organizational Form	8	10	24	42.86	28	9	5	88.1**
Heuristic Education	15	12	15	64.3	25	13	4	90.48**
Clinical Thinking	10	10	22	47.62	30	10	2	95.24**

Note: *P < 0.05, **P < 0.01 versus control group. SA = Satisfied; BSA = Basically Satisfied; DIS = Dissatisfied; SR= Satisfaction Rate (%).



Note: SA = Satisfied; BSA = Basically Satisfied; DIS = Dissatisfied.

Figure 1. Overall teaching satisfaction distribution.

4. Discussion

Educational games are not merely the "gamification" of traditional teaching; rather, they combine educational content with game mechanics to enhance learning motivation and efficiency [10]. Pathology encompasses a vast array of knowledge points and complex morphological changes, which can make traditional teaching extremely challenging [8]. The GIMM model introduced in this study successfully transformed the complex concepts of pathology into hierarchical tasks, thereby increasing students' classroom engagement and positive performance.

In the practice of pathology teaching, GIM has structured the tasks in a game-like, hierarchical manner. It simulated the cooperation model of the clinical medical team through a collaborative scoring system and a ranking mechanism. It also encouraged students to continue self-study outside the classroom with continuous learning incentives. The non-punitive failure model reduced anxiety during the learning process and promoted a positive competition.

The survey on satisfaction with learning and teaching shows that the experimental group had significantly higher satisfaction rates in dimensions such as learning interest (90.48%), classroom interest (88.1%), and clinical thinking cultivation (95.24%) compared to the control group. This is closely related to the precise alignment of the GIMM model with students' psychological motivations. Virtual medals, the opportunity for professor discussions, and other honor rewards satisfy the need for a sense of achievement, while substantive rewards such as affiliated hospital internships and pathological diagrams achieve the connection between learning outcomes and career development. The regularly optimized reward system ensures fairness and participation enthusiasm. Teachers provided targeted assistance in the role of "NPC", achieving a balance between "guided learning" and "autonomous exploration", significantly enhancing students' autonomous learning ability and interdisciplinary integration ability.

Nevertheless, this study has limitations: the sample was confined to one institution and a single organ system module, and long-term learning retention was not assessed. Future investigations should involve multi-center collaborations, incorporate adaptive learning pathways via learning analytics, and leverage immersive technologies such as virtual reality (VR) and augmented reality (AR) to deepen experiential learning.

5. Conclusion

Incorporating gamified incentive mechanisms into pathology laboratory teaching significantly enhances instructional effectiveness and student satisfaction, addressing longstanding issues such as low engagement and insufficient practical training. As digital technologies become further embedded in medical education, gamified teaching is poised to become a transformative force in educational innovation, offering novel pathways for cultivating clinically competent and motivated medical professionals.

Data Availability

The data supporting this study are available from the corresponding author upon reasonable request.

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Conflicts of Interest

The authors declare no conflicts of interest.

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