Center for Management Science Research
ISSN: 3006-5291 3006-5283 Volume 4, Issue 6, 2026

EFFECT OF A GAMIFIED LEARNING INTERVENTION ON DENTAL STUDENTS' CLINICAL PERFORMANCE: A QUASI-EXPERIMENTAL STUDY

Dr. Mohammad Fayaz*[1], Dr. Farhana Gul[2]
[1]Institute of Business and Management Sciences (IBMS)
The University of Agriculture Peshawar, Pakistan
[2]Department of Economics, The University of swabi, Pakistan
[1] mfayaz@aup.edu.pk , [2] farhana@uoswabi.edu.pk

DOI: https://doi.org/10.5281/zenodo.21058509

Keywords
Gamification, Clinical performance, Dental education, Quasi-experiment

Article History
Received on 20 May 2026
Accepted on 17 June 2026
Published on 27 June 2026

Corresponding Author: *
Dr. Mohammad Fayaz*

Abstract

Background: *Clinical performance is a critical competency for dental students, reflecting their technical proficiency and readiness for professional practice. With the growing adoption of educational technologies, gamification has emerged as an innovative approach to enhance engagement, motivation, and learning in educational settings. While prior studies have reported positive effects on knowledge acquisition and cognitive skills, limited evidence has addressed its impact on the clinical performance of dental students. This study examined the effectiveness of gamified learning in improving the clinical performance of dental students.*

Methods: *A quasi-experimental design with pre- and post-test measures was employed. Fifty-two dentistry students were divided into control (traditional instruction, n = 26) and experimental (gamified instruction, n = 26) groups for the study. The clinical performance was assessed using a validated scale. Analysis of covariance (ANCOVA) was conducted with pre-test scores as a covariate to evaluate post-test differences. Logistic regression was used to examine the probability of improved performance based on pre-test scores and group assignment.*

Results: *ANCOVA revealed a non-significant effect of gamified instruction on clinical performance after adjusting for the baseline scores. However, students in the gamified group achieved higher adjusted mean scores than those in the control group, indicating superior clinical-task performance. Logistic regression confirmed that group membership significantly predicted improved outcomes, with students in the gamified group showing higher odds of better performance.*

Conclusion: *Gamified learning can effectively enhance clinical performance in dental education by fostering motivation, engagement, and skill development in students. These findings support the integration of gamification into dental curricula to strengthen clinical training and prepare students for professional practice.*

INTRODUCTION

Background

In the last decade, rapid technological advancement has brought a drastic revolution in every field of life, including medical education. To cope with these challenges and provide technology-based learning environments, universities have significantly developed pedagogies, moving away from traditional lecture-based methods towards more interactive and engaging learning strategies [1]. One such approach is gamification, which refers to the use of game design elements in non-game contexts [2, 3]. Gamification has emerged as an influential strategy for improving practical skills, motivation, and engagement in educational settings [4]. By integrating features such as narrative-based tasks, points, challenges, and feedback, gamified interventions create collaborative and immersive learning experiences [5, 6]. Prior research has shown that such methods can substantially improve academic [7, 8] and can serve as an appealing alternative to traditional teaching methods that frequently struggle to sustain engagement among students.

Similar to other medical fields, dentistry education is technical and challenging, requiring more technical capability, procedural accuracy, and effective application of theoretical knowledge in clinical scenarios [9, 10]. Improving clinical performance is essential, as it directly affects graduates' readiness for professional practice and their capability to offer safe and effective dental care. Gamification addresses motivational and proficiency-related challenges by offering direct feedback and continuous engagement, thereby optimizing learning and practical skill acquisition [11, 12]. Examples of such games include Mentimeter and Kahoot, in which the typical classroom is temporarily converted into a playground where the instructor hosts the competition and the graduates participate as players. These games are complementary tools that facilitate instructors in creating a fun learning atmosphere and engaging graduates in effective learning [13, 14].

Although a plethora of recent research underscores the importance of gamification in medical and dental education [e.g., 1-3, 11-15], however, these studies overlook how gamification directly influences final-year dentistry graduates clinical performance. Prior research has mainly focused on theoretical knowledge and simulation-based skills and ignored whether gamified interventions transform into quantifiable improvements in clinical tasks [16, 17]. In addition, dentistry is a practice-demanding field where clinical proficiency is vital [18-19], and this gap confines our understanding of gamification's true potential in preparing graduates for real-world patient care. Furthermore, most past studies were descriptive or exploratory in nature, making it challenging to establish causal relationships. Therefore, addressing these gaps is timely and essential to determine whether gamification, such as Mentimeter and Kahoot, improves dental graduates' clinical performance.

Material and Methods

Research design

This study employed a quasi-experimental pre- and post-test and correlational design, incorporating both group comparisons and predictive analyses. Through a quasi-experimental or non-randomized design, we evaluated the influence of gamified learning on pre- and post-test dentistry students' clinical performance learning. The quasi-experimental intervention allowed us to assess the impact of post-test clinical performance scores between the experimental and control groups. While the correlational design helped to forecast the associations between pre-test clinical performance scores, group membership, and the probability of accomplishing the anticipated outcome. Specifically, employing this design enables us to comprehensively evaluate both causal effects and relationships among the study variables.

Sample and procedure

A total of 52 (26 from each group) final year dentistry students who actively engaged in various private clinics were recruited for the study. The sample size was deemed sufficient to ensure reliability and representativeness of the study [1, 20, 21]. Participants were divided into two groups: experimental group (received treatment or intervention of gamified learning) and control group (traditional class or did not received intervention). The inclusion criteria include: i) registered final year student, ii) currently involved in practical or clinical practice, and iii) show consent to unconditionally participate in the study. Participants who did not fulfill the above criteria were excluded from the study. The experiment was conducted during March 21 2025 to May 11 2025. Initially, participants completed the pre-test clinical performance test (CPPreT) and the score was calculated as a baseline assessment. After that a two week session was arrange for experimental group that was completely based on gamified learning activities. The traditional classroom was artificially converted into a playground where they engaged in simulation and learning. While the control group were received lectures in traditional classroom settings. After the treatment period, post-test clinical performance scores of both groups were assessed. Before analysis, the collected data was thoroughly examined.

Ethical consideration

The study was approved by the Institutional Review Board (IBR) of Khyber Medical University, Peshawar, Pakistan (letter no. KMUDS/237/25). The detailed research design of the study and the objectives were discussed with the university administration and department head. We also shared the study objectives with the concerned students and ensured the anonymity and confidentiality of their responses. Moreover, we assured them that their participation was voluntary and non-monetary, and that they could withdraw their participation from the study at any time. All procedures were strictly followed in accordance with the Declaration of Helsinki and its amendments.

Research instruments

Clinical performance: Pre- and post-clinical performance was assessed using a 10-item scale adapted from [22]. The sample item is "I maintain patient safety at any time." All items were rated on a five-point Likert scale, where 1 represents strongly disagree and 5 represents strongly agree. The maximum and minimum scores on this scale are 50 and 10, respectively. A higher score indicates greater clinical performance. We found good pre- and post-test reliability of the scale (alpha = 0.842 and 0.865).

Gamified learning: Gamified learning was treated as a dummy variable, where (0) represented the control group and (1) represented the experimental group. Gamified learning was treated as an independent variable in the ANCOVA and as a predictor in the logistic regression analysis.

Statistical procedure

Analyses were performed using SPSS version 26. Initially, we checked all the basic assumptions of ANCOVA, including linearity, normality, homogeneity of variance, and homogeneity of regression slopes. ANCOVA was performed to investigate the effect of group membership on post-test clinical performance, controlling for baseline pre-test clinical performance scores with a 95% confidence interval. The effect size partial eta squared (η^2) was calculated. For logistic regression, we checked the collinearity assumption using the variance inflation factor (VIF) and tolerance. Moreover, model fit was assessed through -2 Log Likelihood, Omnibus Chi-Square, and pseudo R^2 (Cox & Snell, Nagelkerke). Binary logistic regression was employed to predict the likelihood of achieving the desired outcome based on pre-test clinical performance and group membership. Linear regression was applied to investigate the relationship between the pre- and post-test clinical performance. Regression coefficients, standard errors, significance levels, Wald statistics, and odds ratios ((Exp (B)) were reported.

Comprehensive Flowchart

Figure 1 illustrates the flowchart of the study design. Respondents pre-test clinical performance scores were first recorded, followed by assignment to either the gamified (treatment) or control group. Subsequent analyses were performed in parallel. ANCOVA was applied to evaluate the impact of the treatment on post-test scores, controlling for pre-test scores, yielding adjusted means and confidence intervals (CIs). We employed logistic regression to predict a binary outcome using pre-test scores and group assignment as predictors, providing odds ratios and predicted probabilities. This unique design allows for an inclusive examination of both continuous and categorical outcomes while controlling for baseline differences.

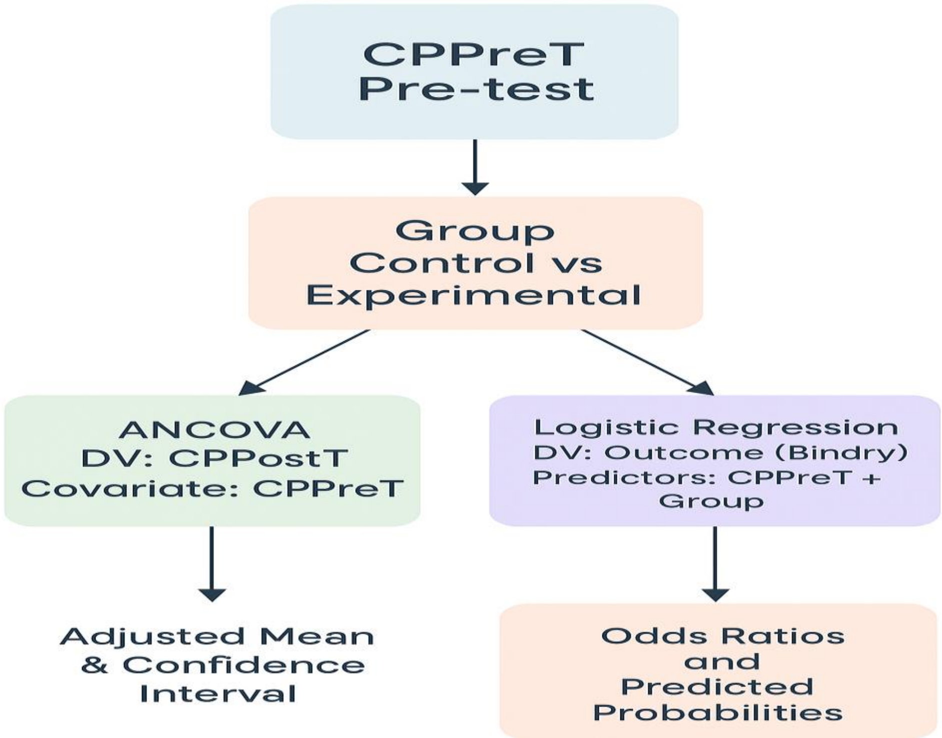

Figure 1: Flowchart of the study methodology

Results

Respondents' demographics show that 61 percent were male students with an average age of 24.3 years. Most participants specialized in oral and maxillofacial surgery (n = 20, 38%), followed by oral and maxillofacial radiology (n = 14, 26%), pediatric dentistry (n = 11, 22%), and prosthodontics (n = 7, 14%). They had an average of 23 hours of clinical practice per week.

Before applying ANCOVA, we tested its basic assumptions and regression analysis. Table 1 highlights the results. Baseline equivalence was confirmed, indicating successful randomization of the participants. The residuals were within the acceptable range, no issue of multicollinearity was observed, and the variances were homogeneous. However, data normality was not sufficiently met as the tests were significant. Although skewness and kurtosis values and graphical inspection showed minor deviations. Prior research suggests that normality issues arise when the sample size is small [23-25]. Overall, the regression and ANCOVA assumptions were adequately met.

Table 1: Assumptions and Residual Diagnostics

Assumption	Test / Output	Result	Interpretation
Baseline Equivalence	Independent t-test (CPPreT): $t(50) = -0.060$, $p = .952$	Groups equivalent	Randomization successful; groups did not differ on pre-test scores.
Normality of Residuals	Shapiro-Wilk = 0.207, $p < .057$; Skewness = -1.015, Kurtosis = -0.417	Slight deviation	Minor departures from normality; acceptable given ANCOVA/regression robustness.
Homogeneity of Variance	Levene's Test (CPPreT): $F = 0.006$, $p = .941$	Equal variances	Variances across groups are homogeneous.
Multicollinearity	VIF = 1.000; Condition Index = 9.703 (<30)	No issue	Predictors are independent; no collinearity concerns.
Residuals / Outliers	Std. Residuals (−2.139 to 2.378), Cook's Distance < 0.15, Leverage < 0.1	Within acceptable range	No influential points or extreme outliers detected.

Table 2 presents the results of the ANCOVA. After controlling for reference point clinical performance, ANCOVA results revealed no statistically significant difference in graduates post-test clinical performance scores between the gamified learning and control groups, $F(1, 48) = 0.544$, $p = 0.464$, partial $\eta^2 = 0.011$. This indicates that the gamified treatment did not have a significant autonomous effect on graduates' clinical performance outcomes (see Figure 2). Conversely, we found that the pre-test score was a very strong predictor of the post-test score, $F(1, 48) = 634.8$, $p < 0.001$, partial $\eta^2 = 0.93$, demonstrating that graduates who scored better at baseline or reference point were far more likely to get higher scores at post-test, irrespective of group assignment. However, the experimental group revealed a higher adjusted mean (40.08) than the control group (38.65), and the overlap in 95 percent confidence intervals signified that this difference was not statistically significant.

Table 2: ANCOVA Results with Adjusted Means

Source / Group	F	Sig.	Partial η^2	Adjusted Mean	95% CI Lower	95% CI Upper
Group	0.544	0.464	0.011	–	–	–
CPPreT (covariate)	634.8	0.000	0.930	–	–	–
Adjusted Means	–	–	–	Control: 38.65	37.70	39.59
	–	–	–	Gamified: 40.08	39.14	41.03

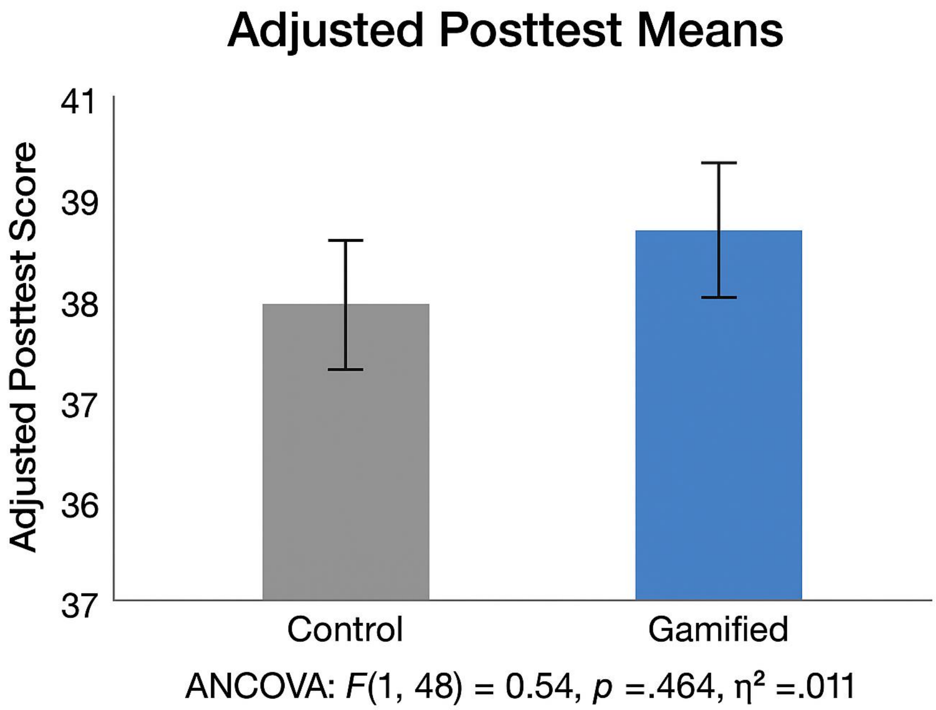

Figure 2. Adjusted Post-test Scores by Group (ANCOVA)

Figure 2 illustrates the adjusted post-test performance scores for the gamified and control groups after adjusting for the pre-test performance scores. The gamified group had a slightly higher adjusted mean (40.08) than the control group (38.65); however, the overall difference was not significant. Conversely, pre-test performance scores strongly predicted post-test performance, signifying that baseline ability was the key driver of post-test performance.

Table 3 reported the regression coefficients between pre-test score and post-test score and between group and post-test score. The pre-test performance score was strongly and significantly related to post-test scores ($B = 0.928$, $p < 0.001$). Similarly, group membership had a moderately significant relationship with post-test performance scores ($B = 1.434$, $p = 0.034$). The findings demonstrate that students in the experimental group had slightly higher post-test scores than those in the control group.

Table 3: Regression Predicting Post-test Performance

Predictor	B	Std. Error	Beta	t	Sig.	R^2 / Adjusted R^2	F (df1, df2)	Sig. F
Constant	3.897	1.440	—	2.706	0.009	0.930 / 0.927	326.478 (2, 49)	0.000
CPPreT	0.928	0.036	0.960	25.440	0.000	—	—	—
Group	1.434	0.658	0.082	2.179	0.034	—	—	—

In addition, we also calculated the difference between pre- and post-test scores (Delta) and found that the gamified group revealed a significant increase in Delta scores compared to the control group (B = 1.423, p = 0.041), which explains the 8% variation in the dependent variable. This shows a small-to-moderate effect of gamified treatment on score performance. Figure 3 also reports the delta difference in graphical form.

Table 4: Regression Predicting Delta (Post–Pre Difference)

Predictor	B	Std. Error	Beta	t	Sig.	R^2 / Adj R^2	F (df1, df2)	Sig F
Constant	1.192	0.479	—	2.489	0.016	0.081 / 0.063	4.414 (1,50)	0.041
Group	1.423	0.677	0.285	2.101	0.041	—	—	—

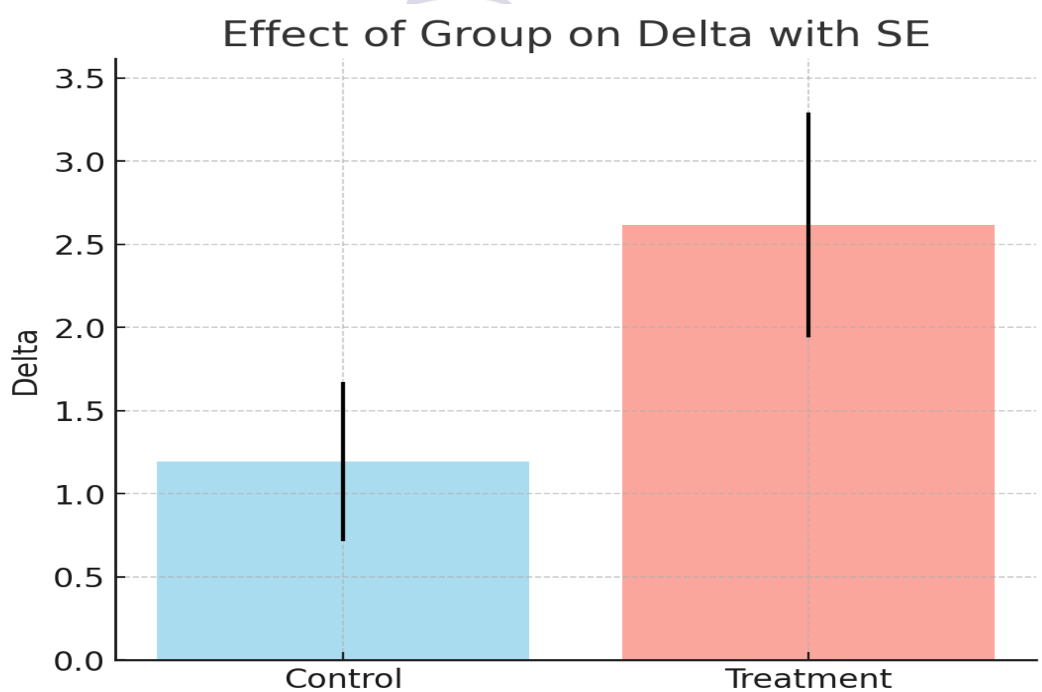

Figure 3: Group effect of Delta

Moreover, to further confirm the insignificant difference, we employed a nonparametric Mann-Whitney U test (Table 5). The results confirmed no statistically significant difference between the control and gamified groups (U = 283.0, p = 0.313). This finding aligns with the earlier ANCOVA, providing additional support that the observed difference in post-test was not statistically significant.

Table 5: Nonparametric Check – Post-test Performance by Group

Group	N	Mean Rank	Sum of Ranks	Mann–Whitney U	Z	p (2-tailed)
Control	26	24.38	634	283	-1.01	0.313
Gamified	26	28.62	744	—	—	—

Tables 6 and 7 highlight the results of the logistic regression. Logistic regression was performed to investigate the impact of pre-test scores and group (gamified vs. control) on the likelihood of achieving the outcome. The overall model showed a modest but significant fit. The model correctly classified 65% of the cases, which is an improvement over chance (50%). The Omnibus Chi-Square test was significant (χ^2 = 5.432, df =1, p = 0.020), signifying that the predictors, as a set, meaningfully enhanced prediction over the null model. The -2 Log Likelihood of 65.120 also recommended a better fit compared to the null model, and the pseudo R^2 values (Cox & Snell R = 0.067; Nagelkerke R = 0.93) specified that the predictors explained a small but meaningful proportion of variance. The regression coefficient of logistic regression indicated that the pre-test score had a strong and significant effect (B = 0.928, SE = 0.036, Wald = 647.232, p < 0.001), with an odds ratio (Exp (B)) of 2.530, signifying that a one-unit change in the pre-test score nearly doubled the odds of achieving the outcome. In addition, group membership was also found to be significant (B = 1.423, SE = 0.677, Wald = 4.404, p = 0.036), with an odds ratio of 4.149, indicating that students in the gamified group were over four times more likely to achieve the outcome compared to the control group. The constant term (B = 3.897, p = 0.009) highlighted the reference point log-odds when both predictors were zero. These results are consistent with the patterns observed in previous ANCOVA and regression analyses.

Table 6. Logistic Regression Model Fit Summary

Statistic	Value	Interpretation
Classification (% correct)	65	Model correctly predicts 65% of cases, showing moderate improvement over chance (50%).
Omnibus Chi-Square	5.432, df = 1, p = .020	Model significantly improves over null, indicating predictors contribute to prediction.
-2 Log Likelihood	65.120	Moderate model fit; lower than null model (72.084), indicating improvement.
Cox & Snell R^2 / Nagelkerke R^2	0.067 / 0.093	Predictors explain a small but meaningful portion of variance (6.7–9.3%).

Table 7. Logistic Regression Coefficients

Variable	B	S.E.	Wald	df	Sig.	Exp(B)	Interpretation
CPPreT	0.928	0.036	647.2	1	0.00	2.53	Significant positive effect; higher CPPreT increases odds of outcome.
Group	1.423	0.677	4.404	1	0.04	4.149	Significant; being in the experimental group increases odds of outcome.
Constant	3.897	1.44	7.044	1	0.01	—	Baseline log-odds when all predictors = 0.

Discussion

This study examined the impact of gamified intervention on dentistry graduates clinical skill performance using a quasi-experimental-cum-correlational design with pre-test and post-test measures. The findings emphasized that graduates in the gamified group meaningfully outperformed the control group in post-test clinical performance (CPPostT), even after controlling for reference point skills (CPPreT). These results offer robust evidence that gamified interventions can effectively improve practical skills in dental education.

The findings of the current study are in line with previous research, emphasizing the positive influence of gamification on skill acquisition and engagement. For instance, prior research has found that gamification effectively enhances task engagement, skills, satisfaction, and learning outcomes among medical students [e.g., 1-4, 22]. Moreover, gamification can improve safety protocols, motivation, and engagement among medical students [5, 7, 11]. In addition, Subhash and Cudney [26] noted that game features such as rewards, challenges, points, and prompt feedback augment both motivation and performance in learning. In dentistry context, Mladenovic and Mladenovic [3] and Song et al. [5] found that gamification help in improving procedural accuracy, patient safety, and competence during simulations. Our findings extend this literature by demonstrating that gamification not only inspires graduates but also transforms into measurable enhancements in clinical performance.

The ANCOVA analysis validated that these enhancements were attributable to the treatment rather than pre-existing differences, underscoring the efficacy of gamification in producing tangible skill gains. Logistic regression further showed that graduates' reference-point performance and group assignment predicted post-test scores. In particular, graduates with higher pre-test skills benefited more from the gamified treatment, signifying a synergistic interaction between existing capability and involvement facilitated by gamification. This is consistent with Deniz et al. [11] and Aboalshamat et al. [12], who stated that students with sufficient basic skills and knowledge are better positioned to leverage gamified challenges for optimal learning outcomes than those without. Our findings underscore the need for adaptive gamification strategies to support graduates across varying skill levels, confirming the justifiable improvement in clinical capability.

Similarly, prior research found that higher satisfaction with games in educational contexts resulted in shorter durations [27]. For instance, Chen et al. [28] used the Geriatric Medication Game in 3 hours laboratory setting to change first-year graduates' perceptions and attitudes towards older peers. Similarly, Shiroma et al. [29] implemented a game-playing methodology to check knowledge improvement among pharmacology students. Moreover, El Tantawi et al. [17] studied the impact of gamification on first-year students' satisfaction and academic writing skills. Their findings suggest that tech-based activities meaningfully improve both satisfaction and academic writing skills among dental students. In addition, Nevin et al. [30] investigated the impact of game-based software on medical students' knowledge acquisition. Deminguez et al. [31] validated that gamified group received higher final scores than the non-gamified group in a course to train university students in use of ICT [32, 33]. Overall, our findings suggest that gamification is a practical and evidence-based strategy for enhancing clinical performance in dentistry students, offering both theoretical and practical contributions to dental education [34, 35].

Practical implications

This study suggests several key implications for practice. First, gamified interventions can improve skills by enhancing technical competence, procedural accuracy, and overall clinical performance. By implanting game-like fundamentals into clinical training, universities can create a learning climate that strengthens precision and nurtures mastery of crucial clinical tasks, which is vital for preparing dentistry graduates for actual patient care. Second, gamification inspires graduates' continuous involvement and motivation. Unlike traditional teaching practices, gamified learning approaches encourage perseverance by rewarding achievements, providing prompt feedback, and empowering graduates to monitor their improvement over time. This sense of advancement inspires learners to practice clinical procedures frequently, leading to deeper learning and higher capability in managing complex cases.

Third, the combination of adapted learning pathways through pre-test evaluations confirms that gamified tasks can be personalized to individual student needs. By recognizing varying reference-point skill levels, universities can adjust the difficulty and focus of gamified practices, thereby offering fair opportunities for all graduates to develop at their own pace. This flexibility lessens the risk of disengagement among weaker graduates while still challenging advanced learners, thereby creating a balanced and comprehensive training atmosphere. Finally, this study emphasizes the significance of curriculum integration of gamified strategies in dental education. Combining gamification with existing teaching modules can bridge the gap between theoretical knowledge and practical skill application, leading to an active learning environment. By embedding gamified tools into simulation labs, preclinical practices, and clinical rotations, dental educators can create more interactive, engaging, and proficiency-driven curricula that better prepare learners for real-world practice.

Limitations and future research avenues

Despite its novel contribution to gamification and dental education literature, our study also suffers from several limitations. First, the use of a non-randomized quasi-experimental design restricts our ability to draw causal conclusions. Future research should employ fully randomized controlled trials to better capture causal inferences. Second, selecting a sample from a single institution may affect the generalizability of the findings to other dental programs or educational settings. In the future, researchers should broaden the study context by including large and diverse samples to offer more generalizable findings. Finally, our study focused on short-term post-test performance scores, and the long-term retention of clinical skills was not effectively assessed. Future research should be designed to effectively capture the long-run effect of gamification on learners' skill acquisition. In addition, examining further gamification elements, such as narrative engagement, collaborative challenges, and adaptive difficulty, could offer insights into enhancing interventions. Similarly, exploring the role of individual differences, such as motivation, baseline skills, and learning styles, can inform the design of tailored gamified programs that boost clinical capability for all graduates.

Conclusion

This study examined the influence of gamified learning on the clinical performance of final-year dentistry graduates. While the gamified group revealed slightly higher adjusted post-test performance scores than the control group, the difference was not statistically significant after accounting for reference point performance. The findings suggest that pre-test performance scores are the strongest predictors of post-test outcomes, highlighting the significance of prior capability. These results indicate that gamification, while not a stand-alone solution, can enhance traditional training by boosting motivation, engagement, and practice opportunities. Integrating gamified programs into dental curricula may therefore support active, student-centered learning and contribute to the development of more competent and practice-ready dental professionals.

References

1. Shafqat MD, Okon II, Rafi A, Javed A, Irshad K. Unlocking learning: evaluating case-based learning versus escape rooms for first-year dental students: a quasi-experimental study. Ann Med Surg (Lond). 2025; 87(7):4080-9. doi:10.1016/j.amsu.2025.108034

2. Nguyen LM, Le C, Lee VD. Game-based learning in dental education. J Dent Educ. 2023; 87(5):686-93. doi:10.1002/jdd.13012

3. Mladenovic R, Mladenovic K. From boring to engaging: using gamification to transform dental education and practice. In: Augmented Reality Games II: The Gamification of Education, Medicine and Art. Cham: Springer International Publishing; 2024: 223-41. doi:10.1007/978-3-031-55120-4_12

4. Schimunda N, de Souza Silva FJ, Fregoneze AP, Petraukas A, Doetzer AD, Spada PC, et al. Gamification as a learning resource for dentistry students–experience report. Rev Contemp. 2023; 3(12):29802-14. doi:10.55852/rcont.v3i12.29802

5. Song YL, Foo LH, Ong MA. Exploring gamified learning for inculcating patient safety concepts in dentistry: A mixed-methods study. Eur J Dent Educ. 2023; 27(3):662-78. doi:10.1111/eje.12856

6. Romli MH, Wan Yunus F, Cheema MS, Abdul Hamid H, Mehat MZ, Md Hashim NF, et al. A meta-synthesis on technology-based learning among healthcare students in Southeast Asia. Med Sci Educ. 2022; 32(3):657-77. doi:10.1007/s40670-022-01528-0

7. Lim J, Ko H, Park J, Ihm J. Effect of active learning and online discussions on the academic performances of dental students. BMC Med Educ. 2022; 22(1):312. doi:10.1186/s12909-022-03385-4

8. Lin GS, Tan WW, Tan HJ, Khoo CW, Afrashtehfar KI. Innovative pedagogical strategies in health professions education: active learning in dental materials science. Int J Environ Res Public Health. 2023; 20(3):2041. doi:10.3390/ijerph20032041

9. Lin GS, Foo JY, Foong CC. Curriculum mapping of a dental materials science course: a reality check and way forward. BMC Med Educ. 2023; 23(1):716. doi:10.1186/s12909-023-04584-7

10. Ihm J, Shin Y, Seo DG. Did clinical reasoning and knowledge questions during Team-Based Learning enhance dental students' performance in esthetic dentistry? J Dent Educ. 2020; 84(4):495-501. doi:10.1002/jdd.12148

11. Deniz HA, Balkan EP, İncebeyaz B, Kamburoğlu K. Effect of gamification applications on success of dentistry students. World J Methodol. 2025; 15(1):97374. doi:10.5662/wjm.v15.i1.97374

12. Aboalshamat K, Khayat A, Halwani R, Bitan A, Alansari R. The effects of gamification on antimicrobial resistance knowledge and its relationship to dentistry in Saudi Arabia: a randomized controlled trial.

BMC Public Health. 2020; 20(1):680. doi:10.1186/s12889-020-08757-1

13. Wang AI, Tahir R. The effect of using Kahoot! for learning–A literature review. Comput Educ. 2020; 149:103818. doi:10.1016/j.compedu.2020.103818

14. Zhang Q, Yu Z. A literature review on the influence of Kahoot! on learning outcomes, interaction, and collaboration. Educ Inf Technol. 2021; 26(4):4507-35. doi:10.1007/s10639-021-01451-w

15. Alkhattab OR. Gamification in endodontic education: a pilot study on student engagement and perceived learning outcomes. BMC Med Educ. 2025; 25(1):1214. doi:10.1186/s12909-025-06801-0

16. Bobich AM, Mitchell BL. Transforming dental technology education: skills, knowledge, and curricular reform. *J Dent Educ*. 2017; 81(9):eS59-64. doi:10.1002/jdd.1133

17. El Tantawi M, Sadaf S, AlHumaid J. Using gamification to develop academic writing skills in dental undergraduate students. Eur J Dent Educ. 2018;22(1):15-22. doi:10.1111/eje.12287

18. Lin GS, Ng YS, Hashim H, Foong CC, Yahya NA, Halil MH, et al. Shaping tomorrow's dentists: a multi-institutional survey of undergraduate dental students' perceptions towards interprofessional education. BMC Oral Health. 2024; 24(1):762. doi:10.1186/s12903-024-03402-z

19. Fatima S, Hong WH, Mohd Noor MN, Foong CC, Pallath V. Evaluating the instructional strategies influencing self-regulated learning in clinical clerkship years: a mixed studies review. Teach Learn Med. 2025:1-9. doi:10.1080/10401334.2025.2456789

20. Lin GS, Foong CC, Abdul Aziz YF. Interactive Online Modules for Dental Education: A Practical Example of Gagne's Nine Events of Instruction. Educ Med J. 2024; 16(3):173-84. doi:10.55768/emj.2024.16.3.173

21. Lohitharajah J, Youhasan P. Utilizing gamification effect through Kahoot in remote teaching of immunology: Medical students' perceptions. J Adv Med Educ Prof. 2022; 10(3):156-62. doi:10.34172/jamp.2022.25

22. Karimian Z, Momeni M, Zarifsanaiey N. Enhancing radiographic interpretation: effects of gamification on medical students' knowledge, skills, and satisfaction—a quasi-experimental study. BMC Med Educ. 2025; 25(1):958. doi:10.1186/s12909-025-06720-y

23. Pfeil M. Assessing the clinical skills performance of nursing students. J Child Health Care. 2003; 7(3):191-206. doi:10.1177/13674935030073004

24. Kim TK, Park JH. More about the basic assumptions of t-test: normality and sample size. Korean J Anesthesiol. 2019; 72(4):331-5. doi:10.4097/kja.d.19.00020

25. Ainur AK, Sayang MD, Jannoo Z, Yap BW. Sample size and non-normality effects on goodness of fit measures in structural equation models. Pertanika J Sci Technol. 2017; 25(2):577-92. doi:10.15546/pjst.2017.25.2.577

26. Subhash S, Cudney EA. Gamified learning in higher education: A systematic review of the literature. Comput Hum Behav. 2018; 87: 192-206. doi:10.1016/j.chb.2018.05.026

27. Hamari J, Koivisto J, Sarsa H. Does gamification work?—A literature review of empirical studies on gamification. In: Proceedings of the 47th Hawaii International Conference on System Sciences. IEEE; 2014:3025-34. doi:10.1109/HICSS.2014.377

28. Chen AM, Kiersma ME, Yehle KS, Plake KS. Impact of the Geriatric Medication Game® on nursing students' empathy and attitudes toward older adults. Nurse Educ Today. 2015;35(1):38-43. doi:10.1016/j.nedt.2014.07.012

29. Shiroma PR, Massa AA, Alarcon RD. Using game format to teach psychopharmacology to medical students. Med Teach. 2011;33(2):156-60. doi:10.3109/0142159X.2010.541897

30. Nevin CR, Westfall AO, Rodriguez JM, Dempsey DM, Cherrington A, Roy B, et al. Gamification as a tool for enhancing graduate medical education. Postgrad Med J. 2014;90(1070):685-93. doi:10.1136/postgradmedj-2014-132261

31. Domínguez A, Saenz-de-Navarrete J, De-Marcos L, Fernández-Sanz L, Pagés C, Martínez-Herráiz JJ. Gamifying learning experiences: Practical implications and outcomes. Comput Educ. 2013;63:380-92. doi:10.1016/j.compedu.2012.12.008

32. Alyousef, M. I., Khattak, S. R., AlWadi, B. M., Bayram, A. T., Dukhaykh, S., & Al Hakami, H. M. (2026). Effects of emotional culture of joy on employee happiness: A moderated-mediation model in hospitality. *Acta Psychologica*, *265*, 106619.

33. Khattak, S. R., Batool, S., Saleem, Z., & Takrim, K. (2016). Effects of social media on teachers' performance: Evidence from Pakistan. *the dialogue*, *11*(1).

34. Khattak, S. R., Rahman, S. U., Saleem, Z., Fayaz, M., Fayaz, M., & Iqbal, K. (2021).

Reverse Mentoring: Improving Technological Skills of Older Peers: A Moderated Mediation Approach. *Multicultural Education*, 7(4), 248-260.

35. Lv, C., Alyousef, M. I., Khattak, S. R., Moorthy, U., Al Hakami, H. M., Alharthi, F. B., ... & Espinosa-Cristia, J. F. (2025). Turning benign envy into engagement: the moderating role of inclusive leadership in nursing. *BMC nursing*, *24*(1), 1399.