

Gamified Large-group Teaching and Higher-order Cognitive Performance in First-year Medical Students: A Quasi-experimental Crossover Study

Cristo Jaisha C^{1,2*}, Aruna B Patil³, Sreelekha D⁴,
Sarala Devi KV², Shivasakthy M¹

¹Institute of Health Professions Education, Sri Balaji Vidyapeeth, Puducherry, India, ²Department of Anatomy, ESIC Medical College & Hospital, Chennai, Tamil Nadu, India, ³Department of Biostatistics, ESIC Medical College, Chennai, Tamil Nadu, India, ⁴Department of Anatomy, Sree Balaji Medical College and Hospital, Chennai, Tamil Nadu, India. *Corresponding Author's Email: cjaisha@gmail.com

Abstract

Large-group teaching is widely used in undergraduate medical education but can provide limited opportunities for active participation, feedback and application of knowledge. Gamification may offer a way to introduce interactive learning elements into classrooms. This study compared gamified and traditional teaching in first-year MBBS anatomy students and examined student perceptions of the two approaches. A quasi-experimental crossover study was conducted among 150 students at ESIC Medical College, Chennai, during the 2025-2026 academic year. Students were divided into two sequences of 75: Group A received gamified teaching for Topic 1 and traditional teaching for Topic 2, whereas Group B received the reverse sequence. Each session lasted 60 minutes. Gamified sessions used team-based and individual activities, diagram labelling, timed identification, clinical case-solving, mapping, online quizzes, scoring, immediate feedback and rewards. Topic-specific 10-item MCQ tests were developed from learning objectives and reviewed by three anatomy experts for content validity. Mean post-test scores were higher after gamified teaching for Topic 1 (9.0 ± 1.1 vs. 7.5 ± 1.7 ; mean difference 1.51; 95% CI 1.05-1.96; $p = 0.0001$) and Topic 2 (9.1 ± 1.0 vs. 7.4 ± 1.5 ; mean difference 1.72; 95% CI 1.30-2.14; $p = 0.0001$). Learning gains were also greater following gamified teaching. Feedback responses comprised 79 gamified and 31 traditional responses, with more favorable perceptions after gamified teaching. The findings support incorporating structured gamification in large-group anatomy teaching, while multicenter studies with longer follow-up and broader measures of higher-order cognition are needed.

Keywords: Cognition, Cross-over Studies, Educational Technology, Medical Education, Problem Solving, Teaching.

Introduction

Medical education requires learners to do more than recall information. Students must apply knowledge to clinical situations, analyse relevant information and use that information to solve problems, abilities that contribute to the development of clinical reasoning and decision-making (1). Large-group teaching remains common in undergraduate medical education because it permits the delivery of a common curriculum to many students while making efficient use of limited faculty time and physical resources (2, 3). Its efficiency, however, may come at the cost of opportunities for discussion, active participation, immediate feedback and application of knowledge, particularly when teaching is predominantly instructor-centred (2-4). These issues are especially relevant in anatomy, where learners must interpret three-dimensional relationships, identify structures and relate

anatomical knowledge to clinical contexts (4, 5). Lectures remain useful for establishing a common knowledge base, but sustaining attention and active participation throughout a large-group session can be difficult. Interactive approaches can create additional opportunities for retrieval, explanation, discussion, problem solving and feedback and may therefore help learners move beyond simple recall towards application and analysis (6). Evidence from large-group medical teaching also suggests that interactive methods can be associated with better learning outcomes and more favourable student perceptions than conventional lecture-only approaches (2, 3). Gamification refers to the deliberate incorporation of selected game elements, such as challenges, points, competition, feedback and rewards, into non-game learning activities (7). In medical and health professions education, gamified approaches

This is an Open Access article distributed under the terms of the Creative Commons Attribution CC BY license (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted reuse, distribution and reproduction in any medium, provided the original work is properly cited.

(Received 25th March 2026; Accepted 24th August 2026; Published 07th October 2026)

have been associated with improvements in engagement, motivation, participation and selected learning outcomes, although the reported effects vary across contexts (8, 9). Recent reviews indicate that the educational value of game elements depends on how they are selected and integrated with learning objectives rather than on competition or rewards alone (7, 8). Different theoretical perspectives provide possible explanations for these effects. Constructivist views emphasize active knowledge construction through interaction and task engagement (9). Cognitive Load Theory draws attention to the amount of mental processing required by an instructional activity and the need to avoid unnecessary cognitive demands (10). Self-Determination Theory proposes that motivation can be supported when learning environments address competence, autonomy and relatedness (11). Structured challenges, collaborative tasks, feedback and recognition of achievement may therefore create conditions that support both participation and meaningful learning.

Research in anatomy and other health-professions settings has reported encouraging findings, but the literature is heterogeneous. Gamification studies have used different combinations of game elements, durations, delivery formats, learner populations and outcome measures, making direct comparison difficult (7, 12). Anatomy-focused work has reported improvements in motivation and, in some settings, academic performance (13), while online game-based platforms have also been associated with improved performance and engagement in histology teaching (14). More recent studies have examined collaborative gamified quizzing and serious games, further supporting interest in active and interactive approaches to medical education (15, 16). However, not all studies report clear academic benefits and findings may depend on the design of the intervention and the type of outcome assessed (12, 16).

An additional limitation is that much of the existing work has been undertaken in small-group, online, or technology-intensive environments (8, 17). These formats can be effective but may require dedicated platforms, additional infrastructure, or considerable faculty preparation. Evidence from large-group teaching suggests that interactive strategies can be implemented in conventional

classrooms, yet comparatively fewer studies have examined structured gamification embedded within routine large-group anatomy teaching (2, 3, 18). Large classes also make sustained interaction more difficult because instructors must coordinate many learners within a fixed time. A low-resource approach that combines active participation, feedback, competition and clinical application within the normal teaching period may therefore have practical value.

Another gap concerns the cognitive outcomes selected for evaluation. Many gamification studies emphasize satisfaction, engagement, motivation, or overall academic performance, whereas fewer explicitly examine performance on assessments intended to move beyond recall. Multiple-choice questions can assess higher-order learning when they are designed around application and problem solving, but they do not capture the full range of clinical reasoning or complex decision-making (19, 20). Differences in subject matter and assessment design further limit the extent to which findings from small-group or technology-mediated interventions can be transferred directly to large-group anatomy teaching.

The present study was designed to address these gaps by evaluating a structured, classroom-based gamification approach during large-group gross anatomy teaching among first-year MBBS students. The intervention used relatively simple resources, including printed diagrams, worksheets, a classroom scoreboard, team activities, clinical cases and selected online quizzes and was delivered within approximately 60-minute sessions. The crossover structure enabled the two student sequences to experience both gamified and traditional teaching across two anatomy topics, reducing reliance on comparisons between entirely different student cohorts. The principal novelty of the study lies in combining a large-group classroom format, low-resource game elements, clinically oriented activities and topic-specific assessments targeting application, analysis and evaluation.

The study therefore aimed to compare gamified and traditional large-group anatomy teaching in terms of post-test performance and pre-test to post-test learning gains and to explore students' perceptions of engagement, motivation, perceived learning and overall satisfaction. By examining both learning outcomes and student perceptions

within the same cohort, the study sought to determine whether structured gamification was feasible to implement in routine large-group teaching and whether it was associated with better performance on the selected topic-specific assessments.

Methodology

Study Design

A quasi-experimental crossover study was conducted to compare gamified learning with traditional teaching in gross anatomy. The crossover structure allowed both student sequences to experience the two instructional approaches across the selected topics. Students were allocated to the two sequences according to odd and even roll numbers; this was an allocation procedure rather than randomization. The design was used to reduce variability attributable to differences between students, while recognizing that topic and sequence effects could not be fully eliminated.

Ethical considerations

Ethical approval was obtained from the Institutional Ethics Committee (IEC) of ESIC Medical College, Chennai (IEC/2025/01/03). Written informed consent was obtained from all participants.

Participants

The study population comprised first-year MBBS students at ESIC Medical College, Chennai, India (approximate GPS coordinates: 13.0342° N, 80.2069° E), during the academic year 2025-2026. A total of 150 students were eligible and all consenting students were included using universal sampling. Group A comprised odd roll numbers ($n = 75$) and Group B comprised even roll numbers ($n = 75$). Group A received gamified teaching for Topic 1 and traditional teaching for Topic 2, whereas Group B received traditional teaching for Topic 1 and gamified teaching for Topic 2. Students who were absent from a particular teaching session did not contribute data to the corresponding analysis; therefore, the number of observations varied across some analyses. Gender, previous academic performance and prior exposure to gamified learning were not collected as study variables and were not included in the analysis. Baseline topic-specific knowledge was assessed using a pre-test before each instructional session.

Interventions

Two gross anatomy topics were selected for the study: Cerebral Hemispheres and Parotid Gland. Both instructional approaches were delivered by the same faculty member to maintain consistency in content coverage and teaching personnel.

Gamified Learning Intervention

Each gamified teaching session was conducted within approximately 60 minutes, including content teaching, gamified activities, scoring and feedback. Students were seated in teams of approximately 10 according to roll-number or attendance order. A team scoreboard was maintained on the classroom whiteboard and updated after each round. Points were awarded according to the performance criteria of each activity and the cumulative score was used to determine the winning team. Participation included both team-based and individual responses. Students worked collaboratively during diagram labelling, drawing, case-solving and mapping activities, while individual responses were incorporated during selected quiz activities. Immediate feedback was provided after each activity.

Cerebral Hemispheres

Round 1 - "Label Me Up": Printed diagrams of the cerebrum were provided to the teams. Students were asked to label the poles, borders and surfaces. The team that completed the task first received an additional point. The responses were then reviewed and feedback was provided.

Round 2 - "Draw Me Up": Following the teaching of the cerebral lobes, students used the same worksheet to draw the sulci and lines that demarcate the lobes. The relevant sulci and gyri on the different cerebral surfaces were subsequently explained.

Round 3 - "How Fast I Am?": Students used the worksheet to label as many gyri and sulci as possible within one minute. The team with the highest number of correct labels received the points assigned to the round. The responses were reviewed immediately.

Round 4 - "Who Is the Expert?": After teaching the functional areas, arterial supply and venous drainage of the cerebral hemispheres, seven clinical case scenarios were projected sequentially. Each case was displayed for approximately two minutes. Team members discussed the cases and recorded their answers in a team notebook. Lots

were used to determine the order in which teams responded. Points awarded for the responses were added to the cumulative scoreboard. At the end of the session, the team with the highest cumulative score was recognized and rewarded with chocolates.

Parotid Gland

For the Parotid Gland session, students were seated in teams of approximately 10 according to attendance order and each team selected a team name. The session began with a clinical case scenario related to Frey syndrome. After teaching the parotid region and parotid bed, students participated in a "Parotid Mapping" activity. Skull printouts were provided to the teams and students were asked to draw the boundaries of the parotid bed and identify the specified coloured structures. Two rounds of an online quiz were then conducted using Quiz.com. The first team member to respond contributed to the team response and the corresponding team received the points awarded for the activity. A "Surgery Expert" round followed, using a clinical scenario related to Frey syndrome. Students discussed the questions within their teams and provided team responses. Scores from the activities were added to the cumulative scoreboard and rewards were provided to members of the winning team. Immediate feedback was given after each activity.

Traditional Teaching Intervention

Traditional teaching sessions were conducted for approximately 60 minutes using didactic lectures, textbook-based explanations and demonstrations in the dissection hall. The same topic-specific learning objectives were addressed as in the corresponding gamified sessions. No team scoring, competition, leaderboard, or rewards were used during the traditional sessions.

Study Procedure

The crossover sequence was implemented as follows: Group A received gamified teaching for Topic 1 and traditional teaching for Topic 2, whereas Group B received traditional teaching for Topic 1 and gamified teaching for Topic 2. For each topic, students underwent a pre-test before the teaching session and a post-test after the intervention. The same topic-specific assessment tool was used before and after the respective teaching session.

Assessment Tools

Learning outcomes were assessed using separate 10-item multiple-choice question (MCQ) tests for each topic, with a maximum possible score of 10 for each assessment. The questions were designed to assess higher-order cognitive domains, including application, analysis and evaluation (19).

Development and Content Validation of the Assessment Tool

Ten MCQs were developed separately for each of the two selected anatomy topics, resulting in a total of 20 MCQs. Ten questions were developed for the Cerebral Hemispheres topic and another 10 for the Parotid Gland topic. The questions were developed from the specific learning objectives of the respective topics and were intended to assess application, analysis and evaluation. The initial questions were reviewed by three subject experts from the Department of Anatomy for relevance, clarity, appropriateness and alignment with the intended learning objectives and cognitive level. Based on the experts' feedback, the questions were revised before administration. This expert-review process was used to establish content validity of the assessment items (20). Formal internal-consistency reliability testing, including calculation of Cronbach alpha, was not performed.

Student Feedback

Student perceptions of the instructional approaches were assessed using a nine-item Likert-scale questionnaire covering engagement, motivation, perceived learning and overall satisfaction. A total of 110 completed feedback responses were available for analysis, comprising 79 responses following the gamified session and 31 responses following the traditional session. These 110 feedback responses represent the completed questionnaires available for the feedback analysis and are distinct from the 150 students enrolled in the study.

Bias Control

Several measures were used to reduce potential sources of bias. The crossover design allowed both student groups to experience both instructional approaches. The same faculty member delivered both interventions and the same topic-specific learning objectives and assessment procedures were used across the corresponding sessions. These measures improved consistency but could

not eliminate the potential influence of instructor-related factors, topic differences, or period effects.

Sample Size

All eligible students were included using universal sampling. No formal a priori sample size calculation was performed.

Statistical Analysis

Data were analysed using IBM SPSS Statistics for Windows, Trial Version 29.0 (IBM Corp., 2023). Continuous variables were summarized as mean $\pm$ standard deviation. Independent-samples t-tests were used for comparisons between gamified and traditional groups, while paired t-tests were used to assess pre-test to post-test changes within each instructional condition (21). A p-value <0.05 was considered statistically significant.

Results

A total of 150 first-year MBBS students were enrolled in the study. Because some students were absent from individual teaching sessions, the

number of observations varied across analyses. The post-test comparisons and pre-test to post-test changes are presented below.

Post-test Comparison Between Gamified and Traditional Teaching

For Topic 1, the mean post-test score was higher after gamified teaching than after traditional teaching (9.0 ± 1.1 vs. 7.5 ± 1.7 ; mean difference 1.51; 95% CI 1.05-1.96; $p = 0.0001$). For Topic 2, the corresponding scores were 9.1 ± 1.0 and 7.4 ± 1.5 , respectively (mean difference 1.72; 95% CI 1.30-2.14; $p = 0.0001$).

Table 1 presents the post-test performance of students under gamified and traditional teaching conditions for the two selected anatomy topics. For both topics, the mean post-test score was higher following gamified teaching than traditional teaching. The table also reports the between-condition mean differences, 95% confidence intervals and corresponding p-values.

Table 1: Post-test Comparison between Gamified and Traditional Teaching

Topic	Teaching condition	n	Mean	SD	Mean difference*	95% CI*	p-value*
Topic 1	Gamified	75	9.0	1.1	1.51	1.05-1.96	0.0001
Topic 1	Traditional	75	7.5	1.7	-	-	-
Topic 2	Gamified	75	9.1	1.0	1.72	1.30-2.14	0.0001
Topic 2	Traditional	75	7.4	1.5	-	-	-

Note: SD = Standard Deviation, CI= Confidence Interval, n = Number of Participants. *Independent-samples t-test; mean difference and 95% CI compare gamified with traditional teaching within each topic.

Pre-test and post-test Comparison within Groups

For Topic 1, the mean pre-test score in the gamified group was 5.4 ± 2.4 and increased to 9.0 ± 1.1 at post-test. The mean improvement was 3.6 points (95% CI 3.1-4.2; paired $t = 13.087$, $df = 73$; $p = 0.0001$). In the traditional group, the mean score increased from 6.0 ± 2.3 to 7.5 ± 1.7 , with a mean improvement of 1.5 points (95% CI 1.1-1.9; paired $t = 7.17$, $df = 74$; $p = 0.0001$).

Table 2 summarizes the pre-test and post-test scores for Topic 1 according to instructional condition and sequence. Scores increased from pre-test to post-test in both conditions, with a larger numerical increase in the gamified sequence. The paired dataset for the gamified condition included 74 complete observations because one student did not contribute paired data.

Table 2: Descriptive Statistics for Pre-test and Post-test Scores for Topic 1

Sequence	Teaching condition	n	Pre-test mean	Pre-test SD	Post-test mean	Post-test SD
Odd	Gamified	74	5.4	2.4	9.0	1.1
Even	Traditional	75	6.0	2.3	7.5	1.7

Note: SD = Standard Deviation, n = Number of Participants. One student in the gamified Topic 1 sequence did not contribute paired pre-test/post-test data; therefore, the paired analysis included 74 complete pairs.

Table 3 presents the paired inferential analysis for Topic 1. The mean gain was larger following gamified teaching than following traditional teaching. The confidence intervals and paired t-

test statistics indicate statistically significant pre-test to post-test changes in both instructional conditions.

Table 3: Inferential Statistics for Pre-test and Post-test Comparison for Topic 1

Teaching condition	n	Mean gain	SD of difference	95% CI	Paired t (df)	p-value
Gamified	74	3.6	2.4	3.1-4.2	13.087 (73)	0.0001
Traditional	75	1.5	1.8	1.1-1.9	7.17 (74)	0.0001

Note: SD = Standard Deviation, CI= Confidence Interval, df = Degrees of Freedom, n = Number of Participants. Paired t-tests compare pre-test and post-test scores within each instructional condition

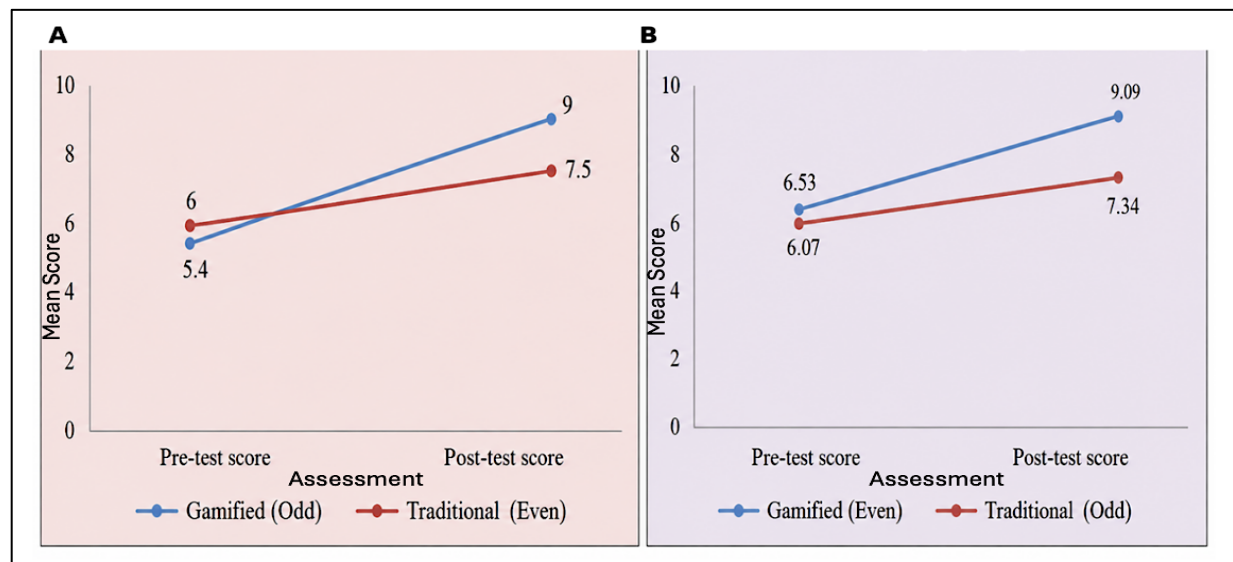
For Topic 2, the traditional teaching group increased from a mean pre-test score of 6.07 ± 1.9 to 7.34 ± 1.5 , with a mean improvement of 1.27 points (95% CI 0.94-1.60; paired $t = 7.608$, $df = 74$; $p = 0.0001$). The gamified group increased from 6.53 ± 1.8 to 9.09 ± 1.0 , with a mean improvement of 2.56 points (95% CI 2.20-2.92; paired $t = 14.276$, $df = 74$; $p = 0.0001$).

Table 4 summarizes the pre-test and post-test scores for Topic 2 by instructional sequence. Both instructional conditions showed improvement after teaching, with a greater numerical increase in the gamified condition. These descriptive statistics provide the basis for the paired inferential analysis presented in Table 5.

Table 4: Descriptive Statistics for Pre-test and Post-test Scores for Topic 2

Sequence	Teaching condition	n	Pre-test mean	Pre-test SD	Post-test mean	Post-test SD
Odd	Traditional	75	6.07	1.9	7.34	1.5
Even	Gamified	75	6.53	1.8	9.09	1.0

Note: n = Number of Participants, SD= Standard Deviation.

**Figure 1:** Mean Pre-test and Post-test Scores by instructional Condition for Topics 1 and 2

(A) Topic 1—Cerebral Hemispheres, (B) Topic 2—Parotid Gland

Figure 1 provides a visual comparison of mean pre-test and post-test scores under gamified and traditional teaching for the two anatomy topics. Panel A shows the pattern for Topic 1, while panel B shows the corresponding pattern for Topic 2. In both panels, the increase from pre-test to post-test is greater for the gamified condition.

Table 5 presents the paired inferential analysis for Topic 2. Both instructional conditions showed statistically significant improvement from pre-test to post-test. The mean gain was greater in the gamified condition, with the corresponding confidence interval and paired t-test statistics reported in the table.

Table 5: Inferential Statistics for Pre-test and Post-test Comparison for Topic 2

Teaching condition	n	Mean gain	SD of difference	SE of mean	95% CI	Paired t (df)	p-value
Traditional	75	1.27	1.44	0.17	0.94-1.60	7.608 (74)	0.0001
Gamified	75	2.56	1.55	0.18	2.20-2.92	14.276 (74)	0.0001

Note: SD= standard deviation; SE= standard error; CI= confidence interval; df =degrees of freedom. Paired t-tests compare pre-test and post-test scores within each instructional condition.

Student Feedback

A total of 110 completed feedback responses were available for analysis, comprising 79 responses following the gamified session and 31 following the traditional session. Responses to the nine-item Likert questionnaire were compared between the two instructional conditions. Positive responses were higher following the gamified session across all nine questionnaire items. The largest differences were observed for whether the session was fun and engaging (89% vs. 26%), whether it was engaging and interactive (92% vs. 48%) and preference for using the method for other topics (92% vs. 52%). Overall satisfaction was reported

by 96% after the gamified session and 68% after the traditional session. The difference for adequacy of time allocation was not statistically significant (89% vs. 74%; $p = 0.0791$).

Table 6 summarizes responses to the nine-item Likert questionnaire comparing student perceptions after gamified and traditional teaching. Positive responses were more frequent following gamified teaching for all nine questionnaire items. The largest differences were observed for engagement, enjoyment, preference for the method in other topics and overall satisfaction, whereas the difference in time adequacy was not statistically significant.

Table 6: Student Perceptions of Gamified and Traditional Teaching

Question	Gamified Positive (%)	Traditional Positive (%)	p-value
a) The learning session was engaging and interactive	92	48	0.0001
b) The learning session was fun and engaging	89	26	0.0001
c) The content was easy to understand and follow	86	55	0.0001
d) The learning method helped me understand the topic better	89	45	0.0001
e) I was motivated to participate actively during the session	90	52	0.0001
f) I would prefer this method of learning for other topics	92	52	0.0001
g) The time allocated for the session was adequate	89	74	0.0791
h) The resources and materials used were appropriate and helpful	91	71	0.0135
i) Overall, I am satisfied with the learning experience	96	68	0.0001

Note: % = Percentage. Positive response = Agree + Strongly Agree. The p-values shown are those reported in the study feedback analysis.

Figure 2 displays the distribution of student perception ratings for the nine questionnaire items under gamified and traditional teaching. The gamified condition shows generally higher ratings across the questionnaire items, with most responses concentrated toward the upper end of the Likert scale. The distribution also illustrates the greater spread and lower ratings observed for several items in the traditional condition.

Discussion

The central finding was that gamified teaching was accompanied by better performance on the selected topic-specific post-tests and larger pre-test to post-test gains than traditional teaching for both anatomy topics. Because the assessments were designed to target application, analysis and

evaluation, the findings suggest better performance on these higher-order-oriented written assessments; they should not be interpreted as evidence that all aspects of higher-order cognition or clinical reasoning were improved.

The magnitude of the post-test differences is relevant to educational interpretation. The mean difference was 1.51 points for Topic 1 and 1.72 points for Topic 2 on a 10-point assessment, corresponding to approximately 15% and 17% of the available score. Although these differences were statistically significant, direct comparison with published effect magnitudes is difficult because gamification studies vary in intervention design, learner characteristics, assessment methods and settings (7, 8, 12, 16). The present

pattern is consistent with literature suggesting that game elements can support learning, but the

size of benefit should be interpreted within the specific context of short, topic-based assessments.

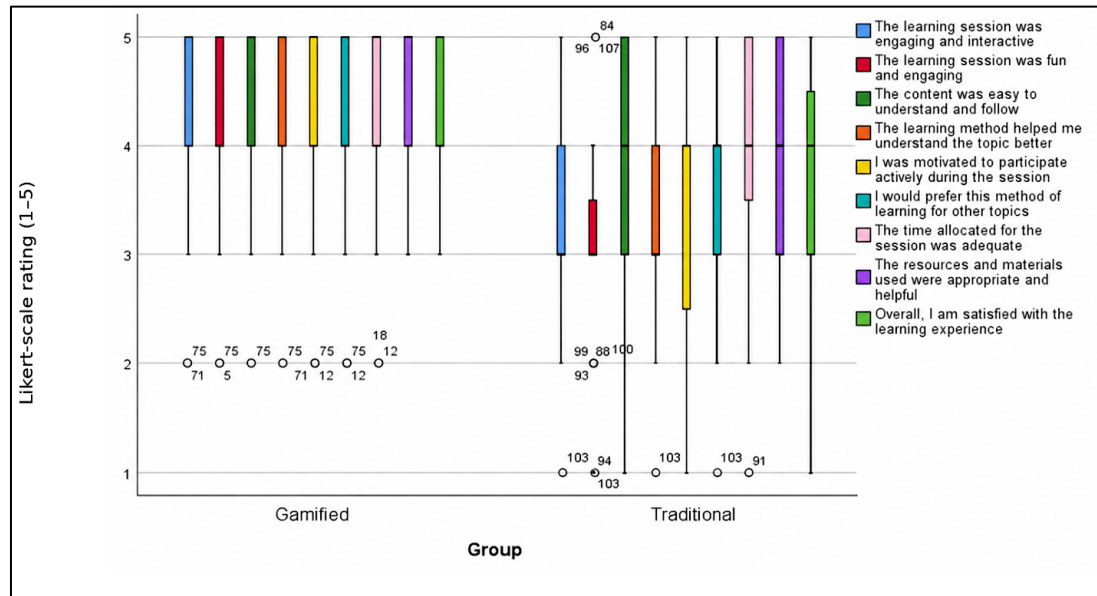


Figure 2: Distribution of Student Perception Ratings for Gamified and Traditional Teaching. Ratings are Shown on A Five-point Likert Scale Across the Nine Questionnaire Items

One plausible explanation is that the gamified sessions required students to retrieve and use anatomical knowledge during the teaching session rather than primarily listen to content. Labelling, drawing, timed identification, mapping and clinical case-solving required students to generate responses, compare ideas with peers and receive immediate feedback. These mechanisms are consistent with educational work emphasizing active participation and timely formative feedback in undergraduate medical teaching (6) and with research identifying structured challenges, feedback and other game elements as important components of effective gamification (22).

The present findings are broadly consistent with previous research reporting improvements in motivation and academic performance following gamified anatomy teaching (13). They are also directionally consistent with evidence from histology teaching in which an online game-based platform was associated with improved performance and engagement (14). However, the present intervention differed substantially from both studies: it was delivered mainly with printed materials, classroom discussion, a whiteboard scoreboard and clinical scenarios in a large-group setting. Such differences in delivery, technology dependence and outcome measurement may explain variation between studies and limit direct quantitative comparison.

Student perceptions were more favorable after the gamified sessions, particularly for engagement, enjoyment, motivation, preference for use in other topics and overall satisfaction. This pattern is consistent with systematic review evidence showing that motivation and confidence are commonly examined outcomes of gamification, although heterogeneity across studies remains substantial (23). At the same time, the present feedback results were not uniformly different: the rating for time adequacy did not differ statistically and the feedback sample was unbalanced, with 79 responses after the gamified session and 31 after the traditional session. The perception findings therefore provide supportive contextual evidence rather than an independent estimate of the intervention effect.

The large-group setting is a clinically relevant feature of the study. Previous work has shown that interactive teaching can be implemented in large classes, while other anatomy and serious-game studies have used small-group or technology-enhanced settings (2, 3, 16, 17). The present intervention required approximately 60 minutes and used readily available classroom materials alongside selected online quizzes. This supports the feasibility of incorporating structured game elements into a large-group anatomy session in the study setting. However, preparation time, faculty workload, cost and resource requirements were

not formally measured. Accordingly, the study does not establish scalability across institutions; it demonstrates feasibility within a single institutional context.

Instructor-related factors also warrant consideration. The same faculty member delivered both instructional approaches, which helped maintain consistency in content coverage, but differences in teaching style, enthusiasm, interaction, pacing, or classroom management may still have influenced the observed differences. The two approaches were also applied to different anatomy topics and differences in topic difficulty, prior familiarity, or sequence effects could have contributed to the results. The crossover structure reduces some between-student variability, but it cannot completely remove topic or period effects.

The assessment strategy is another important boundary on interpretation. The 20 MCQs were developed from topic-specific learning objectives and reviewed by three anatomy experts for content validity. Higher-order MCQs can assess application and problem solving when appropriately constructed (19) and the present questions were intended to assess application, analysis and evaluation. Nevertheless, 10-item topic-specific written tests cannot capture complex clinical reasoning, decision-making, integration across multiple domains, or longer-term retention. The findings therefore support better performance on the selected assessments rather than a definitive claim that gamification improves higher-order cognitive skills across medical education (1, 24).

The educational significance lies in the possibility of introducing active learning into a conventional large-group format without extending the nominal teaching period. This may be particularly useful where class size or staffing limits the routine use of small-group sessions. Audience-response and other interactive approaches have similarly been explored in large classes, suggesting that structured participation can be incorporated without replacing the lecture format entirely (18, 25). However, the single-institution design, short-term outcomes, lack of data on gender, previous academic performance and prior exposure to gamification and absence of a formal cost or workload analysis limit transferability. Further multicenter studies should include broader measures of higher-order cognition and clinical

reasoning, longer-term retention and implementation outcomes such as faculty time, preparation burden and resource requirements.

Educational Implications

For curriculum planners and medical educators, the findings support considering structured, low-resource gamified activities as one option for increasing active participation in large-group sessions. Activities should remain explicitly aligned with learning objectives, with clear scoring rules, immediate feedback and opportunities for students to apply information rather than only accumulate points (7, 22). Faculty development may also help educators design game elements that support learning objectives and manage large-group interaction efficiently.

Strengths and Limitations

Strengths include the crossover structure, inclusion of a relatively large first-year cohort, use of the same faculty member for both instructional approaches and explicit alignment of the assessment items with topic-specific learning objectives. Limitations include the single-institution setting, short-term outcome assessment, absence of demographic and prior-experience variables, unbalanced feedback response numbers, potential topic and period effects and the limited scope of 10-item MCQ assessments for capturing higher-order cognition and clinical reasoning. The absence of formal measurement of faculty workload, cost and preparation time also means that implementation feasibility should not be equated with demonstrated scalability.

Conclusion

Gamified large-group anatomy teaching was associated with higher post-test performance and greater pre-test to post-test improvement than traditional teaching for the two selected anatomy topics and students reported more favourable perceptions of engagement, motivation and overall satisfaction. The study contributes evidence that structured, low-resource game elements can be incorporated into a 60-minute large-group anatomy session without replacing the core content or requiring extensive technology. These findings have practical relevance for educators working with large cohorts, particularly where faculty time, classroom space, or access to small-group teaching is limited. However, the results

should be interpreted within the limits of the single-institution design, allocation by roll number rather than randomization, unbalanced feedback responses, possible topic and period effects and short topic-specific MCQ assessments that cannot capture the full range of higher-order cognition or clinical reasoning. Future multicentre studies should examine longer-term retention, broader measures of higher-order cognition and clinical reasoning and implementation outcomes including faculty workload, preparation time, resource requirements and cost. Such studies would help determine whether the observed educational benefits are reproducible across different institutions and learner populations.

Implications and Contributions

This study shows that structured, low-resource gamified activities can be integrated into a 60-minute large-group anatomy session and were associated with better performance on topic-specific assessments and more favourable student perceptions. The findings are relevant to medical educators seeking feasible active-learning strategies for large cohorts, while broader clinical reasoning outcomes and cross-institutional scalability require further evaluation.

Abbreviations

IEC: Institutional Ethics Committee, MCQ: Multiple Choice Question.

Acknowledgement

The authors thank the first-year MBBS students of ESIC Medical College, Chennai, for their cooperation and participation in the study.

Author Contributions

Cristo Jaisha C: conceptualization, Study Design, Data Curation, Methodology, Formal Analysis, Writing, Editing, Aruna B Patil: Data Analysis, Supervision, Review, Application of Statistical Techniques, Sreelekha D: Conceptualization, Data Curation, Formal Analysis, Supervision, Visualization, Writing, Review, Resources, Editing, Sarala Devi KV: Review, Supervision, Editing, Shivashakthi M: Review, Supervision. All authors approved the final version of the manuscript.

Conflict of Interest

All the authors declare no conflicts of interest.

Data Availability

Data are available from the corresponding author on reasonable request.

Declaration of Artificial Intelligence (AI) Assistance

ChatGPT (GPT-5.6 Luna) was used for language refinement, editorial review and formatting assistance during manuscript preparation. It was not used to generate, analyze, or interpret the study data or statistical results. Figures 1 and 2 were generated by the study statistician using statistical software and were not generated or modified using generative AI. All AI-assisted output was reviewed and verified by the authors, who retain responsibility for the accuracy and integrity of the final manuscript.

Ethics Approval

This study was approved by the Institutional Ethics Committee of ESIC Medical College, Chennai (IEC/2025/01/03). Written informed consent was obtained from all participants.

Funding

None.

References

1. Cooper N, Bartlett M, Gay S, *et al.* Consensus statement on the content of clinical reasoning curricula in undergraduate medical education. *Med Teach.* 2021;43(2):152-9. doi: 10.1080/0142159X.2020.1842343
2. Boedeker P, Schlingmann T, Kailin J, *et al.* Active versus passive learning in large-group sessions in medical school: a randomized cross-over trial investigating effects on learning and the feeling of learning. *Med Sci Educ.* 2025;35(1):459-67. doi: 10.1007/s40670-024-02219-1
3. Bala S, Babu S, Muralidharan S, *et al.* Comparison of traditional lecture and interactive teaching methods in large group teaching of non-communicable diseases: a quasi-experimental study. *Healthline.* 2024;15(2):107-12. doi: 10.51957/Healthline_624_2024
4. Sharmin N, Chow AK, King S. Effect of teaching tools in spatial understanding in health science education: a systematic review. *Can Med Educ J.* 2023;14(4):70-88. doi: 10.36834/cmej.74978
5. Verma A, Pasricha N, Chaudhary A, *et al.* Interactive quiz-based anatomy teaching for medical undergraduate students. *Cureus.* 2024;16(1):e52353. doi: 10.7759/cureus.52353
6. Chun S, Liang C, Thomann C, *et al.* Art in Anatomy session as a method of formative feedback in preclerkship medical education. *Adv Physiol Educ.* 2025;49(1):210-8. doi: 10.1152/advan.00233.2024

7. Aster A, Laupichler MC, Zimmer S, *et al.* Game design elements of serious games in the education of medical and healthcare professions: a mixed-methods systematic review of underlying theories and teaching effectiveness. *Adv Health Sci Educ Theory Pract.* 2024;29(5):1825-48. doi: 10.1007/s10459-024-10327-1
8. Khazaei MR, Hosseini MA, Ramezani G. Gamification in medical sciences education: a scoping review. *Recent Prog Med.* 2025;116(5):291-301. doi: 10.1701/4495.44949
9. Chand S. Constructivism in education: exploring the contributions of Piaget, Vygotsky and Bruner. *Int J Sci Res.* 2023;12(7):274-8. doi: 10.21275/SR23630021800
10. Baxter KA, Sachdeva N, Baker S. The application of cognitive load theory to the design of health and behavior change programs: principles and recommendations. *Health Educ Behav.* 2025;52(4):469-77. doi: 10.1177/10901981251327185
11. Ryan RM, Deci EL. Self-Determination Theory. In: *Encyclopedia of Quality of Life and Well-Being Research.* Cham: Springer. 2023:6229-35. doi: 10.1007/978-3-031-17299-1_2630
12. Huang WD, Loid V, Sung JS. Reflecting on gamified learning in medical education: a systematic literature review grounded in the Structure of Observed Learning Outcomes (SOLO) taxonomy 2012-2022. *BMC Med Educ.* 2024;24(1):20. doi: 10.1186/s12909-023-04955-1
13. Urrejola-Contreras G, Pérez MA, Marciel ME. Gamification: intervention experience to improve motivation and performance in anatomy. *Rev Investig Innov Cienc Salud.* 2025;7(1):1-16. doi: 10.46634/riics.324
14. Felszeghy S, Pasonen-Seppänen S, Koskela A, *et al.* Using online game-based platforms to improve student performance and engagement in histology teaching. *BMC Med Educ.* 2019;19(1):273. doi: 10.1186/s12909-019-1701-0
15. Moin H, Zafar S, Ashraf R, *et al.* The power of play-based learning: evaluating the impact of collaborative gamified quizzing on medical students' learning through the lens of Kirkpatrick's framework. *BMC Med Educ.* 2026;26(1):411. doi: 10.1186/s12909-026-08766-y
16. Al Habsi T, Alibrahim H, Al Zaabi A, *et al.* Are serious games an effective teaching tool in anatomy education? A systematic review. *Appl Sci.* 2025;15(5):2474. doi: 10.3390/app15052474
17. Fonseca GRBC, Tipoe GL, Ganotice FA. Facilitating active learning of sectional anatomy with technology-enhanced small-group tasks: assessment of knowledge gains, technology usability and students' perceptions. *Clin Anat.* 2024;37(7):769-77. doi: 10.1002/ca.24190
18. Keadkraichaiwat I, Sitticharoon C, Lertsiripatarajit V, *et al.* Effects of using audience response systems (Kahoot and Google Forms and Sheets) on learning of medical students in a large class: a questionnaire-based retrospective study. *Educ Inf Technol.* 2024;29:17539-63. doi: 10.1007/s10639-024-12548-8
19. Xiromeriti M, Newton PM. Solving not answering. Validation of guidance for writing higher-order multiple-choice questions in medical science education. *Med Sci Educ.* 2024;34(6):1469-77. doi: 10.1007/s40670-024-02140-7
20. Yahia AIO. Post-validation item analysis to assess the validity and reliability of multiple-choice questions at a medical college with an innovative curriculum. *Natl Med J India.* 2021;34(6):359-62. doi: 10.25259/NMJL_414_20
21. Xu M, Fralick D, Zheng JZ, *et al.* The differences and similarities between two-sample t-test and paired t-test. *Shanghai Arch Psychiatry.* 2017;29(3):184-8. doi: 10.11919/j.issn.1002-0829.217070
22. Wang YF, Hsu YF, Fang KT, *et al.* Gamification in medical education: identifying and prioritizing key elements through Delphi method. *Med Educ Online.* 2024;29(1):2302231. doi: 10.1080/10872981.2024.2302231
23. Seo YK, Kang CM, Kim KH, *et al.* Effects of gamification on academic motivation and confidence of undergraduate nursing students: a systematic review and meta-analysis. *Nurse Educ Today.* 2024;143:106388. doi: 10.1016/j.nedt.2024.106388
24. Lee CY, Lee CH, Lai HY, *et al.* Emerging trends in gamification for clinical reasoning education: a scoping review. *BMC Med Educ.* 2025;25(1):435. doi: 10.1186/s12909-025-07044-7
25. Finn G, Brown ME, Byrne MHV, *et al.* *Oxford Handbook of Medical Education in Practice.* Oxford: Oxford University Press; 2025. doi: 10.1093/med/9780192848710.001.0001

How to Cite: Jaisha CC, Patil AB, Sreelekha D, Devi SKV, Shivashakthi M. Gamified Large-group Teaching and Higher-order Cognitive Performance in First-year Medical Students: A Quasi-experimental Crossover Study. *Int Res J Multidiscip Scope.* 2026;7(4):437-447. DOI: 10.47857/irjms.2026.v07i04.011413