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Original Article

Effect of flipped classroom, team-based learning, and lecture-based classroom on knowledge and student satisfaction: A quasi-experimental study

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Abstract

Objective: Active teaching is widely used in medical education to engage students and promote active learning. However, there is a paucity of research on how active teaching strategies can be applied to English Language learning in a Medical Education context. This study aimed to evaluate the effects of flipped classroom, and team-based learning on knowledge, and learning satisfaction of health sciences students.

Methods: This quasi-experimental study was undertaken with 82 students who were divided into 3 groups, Flipped Group (FG), Team-based Learning (TBL), and Lecture Group (LG) at Sirjan School of Medical Sciences in 2023. Prior to study, the Oxford Quick Placement Test (OQPT) of 50 items was administered to homogenize students. To compare knowledge, a researcher-made knowledge test of English was administered at the baseline and after the intervention. Students' satisfaction and their perspectives were obtained through a survey. Data were analyzed by Chi-squared, one-way ANOVA, Post hoc Tukey test, and Kruskal-Wallis H tests using SPSS software version 26, and content analysis for the open-ended responses.

Results: Of the 117 students participating in the OQPT, 82 (70.10%) entered the study. They included, 21 (25.60%) males, and 61 (74.40%) females with the mean age of 19.57 ± 1.52 years old. In the post-intervention, the FG scored significantly higher (56.71 ± 16.48) than TBL (51.00 ± 14.23), and the LG (39.41 ± 11.45) ($P < 0.001$). Satisfaction levels were highest in the FG. Students' perspectives varied and were classified into two categories: advantages and challenges, corresponding to each teaching approach.

Conclusion: The FG and TBL approaches significantly enhanced learning and student satisfaction compared to LG. These findings underscore the importance of active engagement in medical education, suggesting that innovative teaching strategies can effectively improve student experiences and academic success.

Keywords: Medical education, Flipped classroom, Team-based learning, Lecture-based classroom

Introduction

Education is a critical factor in the cognitive development of individuals, as well as in the promotion of economic advancement and the enhancement of social cohesion and cultural understanding (1). Educational institutions have experienced a transformation in pedagogical innovation driven by various factors, including technological advancements, globalization, evolving student expectations regarding their learning experiences, and the emergence of collaborative learning environments (2). Consequently, in light of these developments, they are striving to refine educational methodologies to align with the demands of labor markets, address future challenges, and ensure that all individuals are able to realize their potential, thereby facilitating their contributions to societal development (1).

The global prevalence of the English language has led to an increasing demand for the teaching and learning English as a foreign language (EFL) (3), and some countries have acknowledged the importance of EFL as a fundamental educational goal for their students (4). In the context of medical education, proficiency in English has become an essential skill for health sciences students, as it serves as the primary language for communication across various domains, including research, clinical practice, and international collaboration. A significant portion of health sciences literature is published in English, making it imperative for students to develop strong reading and comprehension skills to stay abreast of the latest developments in their field (5). Insufficient

English proficiency can hinder health sciences students from achieving their learning objectives (6), limiting their ability to engage with complex scientific texts and participate in meaningful discussions, ultimately affecting their filed-related knowledge and skills (7). Therefore, innovative teaching strategies that prioritize the enhancement of language skills are vital for preparing students for their future careers.

One effective pedagogical approach involves the implementation of active teaching models, which have been shown to provide greater advantages for students in terms of engagement with learning materials, participation in class activities, and collaboration with peers compared to traditional lecture-based teaching methods (8). Traditionally, lecture-based classrooms have dominated instruction; however, this approach often results in passive learning, which can diminish students learning (9). Innovative teaching models such as flipped classroom (FC) and team-based learning (TBL), which adopt a constructivist philosophy of learning, have gained traction as effective alternatives that foster greater student engagement and improve learning outcomes (10,11). Specifically, these pedagogical approaches (FC and TBL) have emerged as prominent subjects of interest among educators of the English language, and they have garnered significant attention in both research and practical application within this field (12,13).

The flipped classroom approach encourages students to explore instructional content outside of class, allowing classroom time to be dedicated to interactive, hands-on activities that promote deeper understanding. This shift from teacher-led instruction to student-centered learning has been linked to richer learning experiences, typically requiring higher-order learning skills (14,15). Similarly, team-based learning approach promotes collaboration and accountability among students, facilitating problem-solving and application of knowledge to real-world scenarios. Additionally, individual and group readiness assurance assessments are employed to evaluate students' comprehension of the fundamental concepts presented in the pre-class materials (16).

In the context of English language learning, various studies have been done with the special focus on the adoption of the FC and TBL approaches in the broad field of English language teaching. The findings of the study by Ivanytska in 2021 revealed that flipped learning not only made the educational process more effective and innovative, but also led to improved student progress in language learning, increased motivation and engagement, and heightened interest in learning English (17). In a recent systematic review conducted by Pongpanich et al in 2025, the authors examined the implementation of FC in the context of EFL instruction. Their findings indicated that the FC approach significantly improved EFL learners' speaking, listening, and reading competencies, promoted learner autonomy, and alleviated language learning anxiety. However, the authors also noted that despite these advantages, several challenges persist, such as disparities in access to technology, differences in student preparedness, and a lack of adequate training for educators (18). Another study conducted by Fischer and Yang in 2022 emphasized the potential for collaborative and communicative language use afforded by flipped classrooms for EFL students (19). In a similar line, the study undertaken by Kareem in 2021, which focused on the implementation of TBL approach in teaching English to EFL undergraduate students, revealed that a significant majority of the participants favored TBL over traditional learning methods. The results indicated that TBL had a more favorable impact on student engagement in class activities and assignments. Furthermore, while the findings highlighted the positive effects of TBL and the students' overall satisfaction with this pedagogical approach, they also identified various challenges and obstacles associated with its implementation in the classroom (20).

By the same token, in the context of medical education, various studies have highlighted the effectiveness of active teaching strategies in fostering active learning. Nayak et al conducted a study using the case-based readiness assurance process (CBRAP) as a strategy for integrating early clinical exposure within the preclinical phase of the undergraduate medical curriculum in India. Their findings suggest that the implementation of innovative teaching models that engage students actively can enhance learning outcomes (21). Punja et al conducted an evaluation of the efficacy of TBL as an instructional strategy among 128 first-year medical students. Their findings indicated that TBL sessions significantly enhanced student engagement with the course material. A substantial proportion of the participants reported that the incorporation of TBL positively contributed to their comprehension of the subject matter and expressed confidence that it would facilitate improved performance in their examinations (22).

Although previous studies underscore the benefits of the FC and TBL approaches in enhancing students learning outcomes in the context of language learning as well as medical education, research findings have indicated that FC (23,24) and TBL (25,26) have their own disadvantages. In this regard, the overall effectiveness of the FC and TBL in EFL in medical education context remains a topic of ongoing discussion. Thus, it is important to evaluate the effectiveness of FC and TBL each time that they are applied to a new setting. Therefore, in this study, we aimed to evaluate the effects of flipped classroom with team-based learning strategy with that of the traditional lecture-based approach in the English language education course among health sciences students with respect to their knowledge, and learning satisfaction. Our research questions and hypothesis are:

Research questions:

- Evaluate in a non-equivalent comparison group design if active learning through flipped classroom and team-based learning could increase short term knowledge retention.
- Evaluate if active learning through flipped classroom and team-based learning could increase students' satisfaction.
- Describe the students' perspectives on their learning experience with flipped classroom, team-based learning, and lecture-based classroom.

We hypothesize that active learning through flipped classroom and team-based learning will lead to both improved knowledge retention, and increased student satisfaction.

Methods

Research Design and Participants

This study employed a quasi-experimental non-equivalent comparison group design to evaluate the effects of three teaching models on the knowledge as well as the satisfaction of 82 freshman Medical Sciences students majoring in Medicine, Nursing, Anesthesia, Health Information Technology, Environmental Health Engineering, Occupational Health and Safety Engineering, laboratory, and Public Health at Sirjan School of Medical Sciences in 2023. The demographic information of participants is depicted in Table 1. This study was ethically approved by the Ethics Committee of Kerman University of Medical Sciences under the code number: IR.KMU.REC.1403.177.

Research Context

The Sirjan School of Medical Sciences, which is located in Sirjan, Iran, is a newly established institution that offers undergraduate programs in various health science disciplines, accessible through an entrance examination. In addition to a range of health sciences programs, students have the opportunity to pursue a degree in general medicine. At the time of this research, the student population at the School was approximately 650. The educational offerings at this institution are structured according to the curricula approved by the Ministry of Health and Medical Education. In accordance with the mandated curriculum, English language instruction is compulsory, and adherence to this requirement is expected from all medical universities and schools in Iran. The curriculum stipulates that all students must commence their English language education at one of the pre-university levels 1 or 2, or through general English language courses at the onset of their academic journey.

Inclusion and Exclusion Criteria

Students were selected based on census sampling to participate in this study. The inclusion criteria encompassed: 1) selection of the Pre-English course one; 2) completion of the Oxford Quick Placement Test; 3) participation in pre-and-posttest assessments; and 4) willingness to participate in the study. Conversely, students were excluded if they: 1) failed to attend the classroom for more than 3 sessions; 2) had previous experience in FC, and TBL approaches; and 3) had physical or psychiatric symptoms that could impair their ability to provide informed consent.

Control of Confounding Variables

To minimize the potential influence of confounding variables, several measures were undertaken. Firstly, prior to the intervention, the Oxford Quick Placement Test (OQPT) was administered to all eligible students to assess baseline English proficiency and ensure homogeneity across groups. Secondly, participants were randomly allocated to the Flipped Classroom, Team-Based Learning, or Lecture groups using a lottery method performed by an independent research assistant not involved in teaching or assessment, thereby reducing selection bias. Thirdly, all groups received identical course content, instructed by the same instructor, in similar classrooms with equivalent audiovisual facilities, and over the same semester duration, which helped control for environmental and teaching quality factors. Moreover, demographic factors (age, gender, marital status, residency status, and self-reported enthusiasm for learning English) were collected and statistically compared across groups using Chi-squared tests. No significant differences were found, indicating baseline comparability. By applying these strategies, the potential impact of confounding variables on measured outcomes was minimized.

Research Approach

All Bachelor of Science students who were enrolled at Sirjan School of Medical Sciences entered the study. To homogenize students, a placement test, the Oxford Quick Placement Test (OQPT), was administered to measure the participants' English Language proficiency level prior to the commencement of the study. Students had no previous experience of attending language institutes; they had studied English only at high school. Furthermore, the students indicated that they were not enrolled in any language learning courses outside of the classroom during the duration of the study. The initial pool of participants consisted of 117 students. Following the administration of the Oxford Quick Placement Test (OQPT), 82 students who met the inclusion criteria were selected for the study. Random allocation was performed using a simple lottery method to approximate randomization, ensuring each of the 82 eligible students had an equal (approximately 1/3) probability of assignment to one of the three groups. This method, overseen by an independent research assistant blinded to the study hypotheses, aimed to balance groups as closely as possible while minimizing selection bias (e.g., by drawing lots sequentially until group sizes

were met: FG n = 28, TBL n = 30, LG n = 24). Baseline equivalence was confirmed via non-significant pre-test differences ($P = 0.136$).

Given the census sampling from the fixed cohort (n = 82 eligible), no a priori sample size calculation was conducted. Post-hoc power analysis (GPower v3.1; ANOVA, effect size f = 0.45 based on observed means/SDs, $\alpha = 0.05$, 3 groups) indicated power = 0.95.

At the beginning and at the end of the term, students' learning in each group was measured through a researcher-made knowledge test of English. A post-test on their satisfaction of the teaching approach they were taught, and their perspectives was obtained through open-ended questions.

The Pre-English course curriculum focuses on vocabulary development, basic grammar, and reading comprehension. All the three groups were instructed by the same course material and instructor. Each teaching session based on the three approaches was 90 minutes, and students attended English classes one day during the week and were instructed for a total of 12 sessions. All classes were held in classrooms with a capacity of around 35 students with audio-visual equipment. Totally, 12 readings, 12 grammatical topics, and 120 vocabulary items were covered. Prior to the initiation of the study, the research objectives were elucidated to all students and any queries from the students were addressed by a member of the research team. Students had the freedom to opt out of the research at any time.

Approach to Learning Assessment

In the context of learning assessment, it is crucial to recognize the differing cognitive demands posed by descriptive and objective questions. Descriptive questions, often open-ended, encourage students to engage in higher-order thinking by requiring them to synthesize information, analyze concepts, and apply their knowledge creatively. This type of assessment fosters critical thinking and allows for a deeper exploration of students' understanding and interpretations of the material. Conversely, objective questions, such as those utilized in the researcher-made knowledge test of English in this study, primarily evaluate students' recall and recognition of factual information. While they can effectively measure specific knowledge and comprehension levels, they may not fully capture the nuances of students' cognitive processes or their ability to think critically about the subject matter.

In light of the above significant issue, we implemented a multiple-choice question (MCQ) format for the assessment of students learning. The MCQs were designed and classified in accordance with the Bloom's taxonomy (27,28). Bloom's taxonomy serves as a practical framework that delineates a hierarchy of cognitive skills, which encompasses the categories of remembering, understanding, applying, analyzing, evaluating, and creating. We categorized questions at the remember and understand levels as low-level questions and questions at the apply and analyze levels as high-level questions, according to the framework used in the Stringer et al study (29). In this context, 50% of the questions (25 out of 50) were classified as low-level, while the remaining 50% were categorized as high-level. Specifically, the low-level category comprised 10 items related to grammar, 10 items pertaining to vocabulary, and 5 items focused on reading comprehension. By including both low-level and high-level questions, the assessment captured a comprehensive view of students learning. In this regard, the learning assessment not only measured recall, but also took into account the application and analysis of knowledge.

Teaching Models

Flipped Classroom Approach

Pre-class

Students accessed instructor-prepared videos and PowerPoints one week before class to review grammar, vocabulary, and reading materials independently and note questions for clarification.

In-class

After a short introduction, students discussed and solved tasks based on pre-class materials. Peer instruction and group problem-solving were used to enhance understanding. The instructor and peers provided interactive feedback during grammar, vocabulary, and reading exercises.

Post-class

No assigned homework; students were encouraged to review materials to reinforce learning. Activities were designed to foster higher-order thinking per Bloom's taxonomy—application, analysis, synthesis, evaluation, collaboration, and decision-making (30).

Team-Based Learning Approach

Pre-class

Students received voice-embedded PowerPoints on grammar, vocabulary, and reading one week in advance to preview key concepts.

In-class

Each session began with a 15-item Individual Readiness Assurance Test (IRAT), followed by a Team RAT (TRAT) in six groups (A–F). Teams reported answers simultaneously; the instructor explained rationales and managed appeals. Scores included 60% IRAT and 40% TRAT, excluded from curricular grading.

Post-class

Key points were summarized; students reviewed materials

afterwards. Subsequent exercises followed the TBL 4S principles: significant problem, same problem, specific choice, and simultaneous report.

Lecture Classroom Approach

Pre-class

The instructor provided feedback on homework from previous sessions; no digital materials were shared.

In-class

Sessions included lectures on grammar, vocabulary, and reading using examples and whiteboard explanations, followed by textbook activities (Active Skills for Reading 1). Students participated actively and received clarifications.

Post-class

Homework exercises were assigned for the next session, and students were advised to review materials to consolidate understanding.

Differences between FC and TBL

While both approaches aim at active student engagement, the Flipped Classroom emphasizes pre-class individual preparation and reflection, whereas Team-Based Learning relies more on structured group collaboration and readiness assurance tests. Despite similarities in promoting active learning and problem-solving, TBL involves more assessment-oriented components, while FC encourages learner autonomy and flexibility.

Data collection

In order to ensure the homogeneous entry of participants before the application of each teaching model, the Oxford Quick Placement Test (OQPT) was administered. This test consisted of 50 items in multiple-choice format, measuring vocabulary (20 questions), grammar (20 questions), and reading comprehension (10 questions). The validity of the test is well-established, and numerous studies have indicated that it possesses a high level of reliability (31,32). In the present study, the reliability of this test, as assessed using the Kuder-Richardson 21 formula, was found to be notably high, with a coefficient of 0.85. Students' placement in the Pre-English courses was determined based on a standardized national English proficiency assessment, which is part of the Ministry of Health and Medical Education's curriculum policy for health sciences programs in Iran.

Furthermore, as part of the study protocol, a researcher-made knowledge test of English was developed to measure students' English knowledge before and after the intervention. In this regard, a pretest consisting of 50 Multiple-choice Question (MCQs) on knowledge was administered to all students prior to the study. Also, a posttest assessment in the same format and number at the end of the study was completed by students. Pre-and-posttest questions were developed based on the topics covered during the teaching sessions and included vocabulary (N = 20), grammar (N = 20), and reading comprehension (N = 10) sections. To ensure the validity and relevance of the questions, the items were subjected to expert evaluation. In this regard, the content validity of the questions was checked by experts' judgments. Two associate professors and two assistant professors of applied linguistics checked the test content to see whether it corresponded to the items of the textbook, *Active Skills for Reading 1,* (33) taught during the classes. This ensured the appropriateness and clarity of the questions. To assess the reliability of the questions, the knowledge pretest and posttest were piloted on a sample of 16 students who were similar to the students in the main study. Using the test-retest method, participants completed the same set of questions with a time interval of two weeks between the administrations. The internal consistency of the questions was determined using Cronbach's alpha coefficient, which yielded a value of 0.86. This indicates a satisfactory level of reliability, suggesting that the questions consistently measure the intended constructs. The minimum and maximum number of the test was from 0 to 100, with higher scores indicating a greater level of proficiency in the assessed areas. Pre- and post-tests employed parallel but equivalent forms drawn from the same validated item pool, ensuring comparability without identical questions to reduce practice effects. Item analysis from the pilot sample (n = 16) yielded a mean difficulty index of 0.55 (SD = 0.12; range: 0.35-0.75, ideal 0.3-0.7) and mean discrimination index of 0.42 (SD = 0.15; range: 0.25-0.68, > 0.2 acceptable), confirming item quality.

The satisfaction of students regarding the flipped classroom, team-based learning, and lecture-based classroom approaches were assessed at the end of the study through a survey instrument containing 12 questions with an additional open-ended question to allow for more qualitative responses. Students' satisfaction was quantified by using a five-point Likert-type scale ranging from 1 (strongly disagree) to 5 (strongly agree). The items of this survey were developed by literature review (34,35) and were content validated by four Medical Education experts and the reliability of the survey was $\alpha = 0.83$. The English language version of the survey instrument is provided in the supplementary material section. To better understand students' perceptions of the three teaching models, they were asked an additional open-ended question: "What specific aspects of this teaching approach do you believe enhanced or hindered your learning experience?".

The study included both independent and dependent variables defined as follows:

- Independent variable: Teaching method, categorized into three instructional approaches: Flipped Classroom (FG), Team-Based Learning (TBL), and

Lecture-Based classroom (LG).
- Dependent variables:
- Knowledge scores: Continuous measures obtained from pre- and post-tests, each scored out of 100 points.
- Satisfaction: Ordinal variable derived from students' ratings on Likert-scale items assessing their satisfaction with the teaching method, with a potential cumulative score.
- Perspectives: Qualitative data collected from open-ended questions exploring participants' opinions about the teaching approaches.

English learning enthusiasm was self-reported as a categorical variable (high, moderate, low) via a single-item survey question: 'How enthusiastic are you about learning English?' (measured on a 3-point scale: 1 = low, 2 = moderate, 3 = high). This was included as a baseline covariate to assess motivational differences.

Quantitative and Qualitative Data Analysis

Quantitative analysis

Demographic characteristics were analyzed using Chi-squared tests for categorical variables and one-way ANOVA for continuous variables (e.g., age). Knowledge outcomes were compared using one-way ANOVA, followed by an ANCOVA to adjust for pre-test scores. To account for clustering in the Team-Based Learning (TBL) group, where students were nested in teams of five, a linear mixed-effects analysis of covariance (ANCOVA) was used to analyze post-test knowledge scores. This model adjusted for intra-team correlation, with 'team' as a random effect (ICC = 0.12, estimated from pilot data). Fixed effects included the teaching method (Flipped Classroom, TBL, Lecture-Based) and pre-test scores as a covariate to control for baseline differences. The model was fitted using restricted maximum likelihood (REML) in IBM SPSS Statistics (version 26) with the MIXED procedure. Assumptions, including normality of residuals, were verified using diagnostic plots (e.g., Q-Q plots). Satisfaction scores were analyzed using the Kruskal-Wallis H test due to non-normal distribution. All statistical analyses were conducted using IBM SPSS Statistics (version 26), with a significance threshold of $P < 0.05$.

The Class Average Normalized Gain (CANG) was calculated to quantify the improvement in students' knowledge between pre-test and post-test assessments while accounting for initial performance differences. This index reflects the proportion of possible improvement actually achieved by a group and is computed using the standard formula proposed by Hake (1998):

$$\text{CANG} = \frac{(\text{Meanpost} - \text{Meanpre})}{100 - \textit{Meanpre}}$$

where Mean_{pre} and $\text{Mean}_{\text{post}}$ denote the average pre-test and post-test scores, respectively. The resulting value ranges from 0 to 1, with higher values indicating greater learning gains. The CANG values for each teaching model were then compared using one-way ANOVA followed by Tukey post-hoc tests to identify significant differences among groups.

Qualitative analysis

The qualitative component consisted of analyzing the open-ended responses regarding students' perspectives on the teaching approaches. A conventional content analysis approach (36) was adopted. Two researchers independently read all responses several times to become familiar with the data. Open coding was then performed line-by-line to identify and label meaningful statements. The codes generated by each researcher were compared, and inter-rater agreement was assessed using percent agreement due to the simplicity of single-word and short-sentence responses. Initial percent agreement was 85% across 164 coding units. Any disagreements were discussed until consensus was reached. Codes with similar meanings were grouped into subcategories, which were further organized into the two main categories of advantages and challenges. To enhance the trustworthiness of the analysis, we maintained an audit trail of coding decisions and sought peer debriefing from a third researcher who reviewed and confirmed the coding framework. Percent agreement was deemed sufficient given the straightforward nature of the responses, which reduced the need for chance-corrected metrics like Cohen's kappa (37).

Results

A total of 117 students took part in the Oxford Quick Placement Test. Based on the pre-specified threshold of an OQPT score below 50, 82 (70.10%) students entered the study. This score cut-off, in line with the Ministry of Health and Medical Education guidelines, identifies students who are required to enroll in Pre-English Course 1.

Table 1 presents the demographic characteristics and field of study of the 82 participating students across the three teaching methods (Flipped Classroom, Team-Based

Table 1. Participants' Demographic and Academic Information

Field of Study	N	%
Medicine	5	6.0
Nursing	21	25.7
Anesthesia	8	9.8
Health Information Technology	6	7.3
Environmental Health Engineering	5	6.0
Occupational Health and Safety Engineering	14	17.0
Laboratory Sciences	17	20.8
Public Health	6	7.3
Total	82	100

Mean age = 19.57 ± 1.52 years; Males = 21 (25.6%), Females = 61 (74.4%); Class attendance rate = 100% in all groups.

Learning, and Lecture-Based Classroom).

Demographic characteristics were compared among the three teaching groups using Chi-squared tests for categorical variables and a one-way ANOVA for the continuous variable (age). No statistically significant differences were found across groups ($P > 0.05$) (Table 2).

The Figure 1 illustrates the mean pre-test and post-test scores of students across three distinct teaching methods. The x-axis represents the instructional groups, and the y-axis denotes the scores obtained.

Knowledge outcomes were compared using ANOVA, ANCOVA (controlling for pre-test scores), and Mixed-Effects ANCOVA (accounting for TBL clustering, ICC = 0.12) (Table 3). Significant group differences were observed ($P < 0.001$), with flipped and team-based learning outperforming lecture-based (post-hoc details in Table 3). As findings highlight, before the intervention, the mean scores indicated that the lecture-based classroom had a mean of 34.50 (SD = 12.63), while the flipped learning classroom and team-based learning showed higher means of 40.53 (SD = 15.26) and 41.43 (SD = 11.92), respectively. Before the intervention, there were no statistically significant differences in students' baseline knowledge across teaching models ($P = 0.136$). After the intervention, mean post-test scores improved in all groups. Flipped learning achieved the highest mean score (56.71 ± 16.48), followed by team-based learning (51.00 ± 14.23) and lecture-based learning (39.41 ± 11.45). Group differences were statistically significant ($P < 0.001$), with post-hoc comparisons showing that both flipped and team-based learning outperformed the lecture-based approach, and that the flipped learning model yielded the highest overall effectiveness. Mixed-effects ANCOVA confirmed these findings while accounting for team clustering.

To address the quasi-experimental design and potential baseline imbalances, an ANCOVA was performed with post-test scores as the dependent variable, teaching

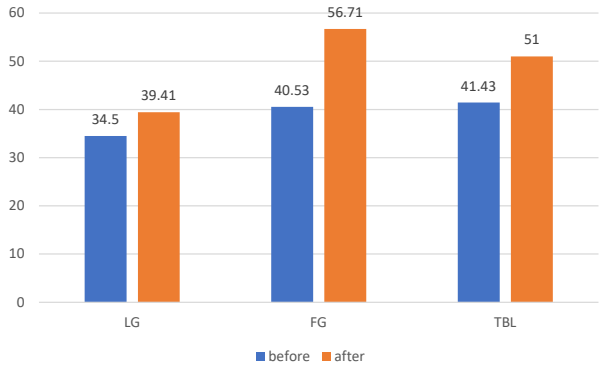

Figure 1. Comparison of Pre-test and Post-test Scores of Students in Three Teaching Methods

Table 2. Distribution of study participants in FG, TBL, and LG based on the demographic characteristics

Variables	Study sample frequency (%)	Teaching models			Statistics χ^2 (df, 95% CI, Effect Size)	*P* value
		Flipped learning classroom (N = 28)	Team-based learning (N = 30)	Lecture-based classroom (N = 24)		
Gender						
Male	21 (25.60%)	7 (33.33%)	7 (33.33%)	7 (33.33%)	$\chi^2 = 0.24$ df = 2 95% CI [-0.15, 0.18] φ = 0.05	$P = 0.885$
Female	61 (74.40%)	21 (34.43%)	23 (37.70%)	17 (27.87%)		
Mean age						
years		19.37 ± 1.52	19.62 ± 1.56	19.73 ± 1.52	F = 0.48 (df = 2, 79), $\eta^2 = 0.01$	$P = 0.818$
Marital status						
Single	75 (91.46%)	25 (33.33%)	29 (38.67%)	21 (28.00%)	$\chi^2 = 1.69$ df = 2 95% CI [-0.10, 0.25] φ = 0.14	$P = 0.429$
Married	7 (8.54%)	3 (42.86%)	1 (14.28%)	3 (42.86%)		
Residency status						
Dormitory	70 (85.37%)	22 (31.42%)	27 (38.58%)	21 (30.00%)	$\chi^2 = 1.63$ df = 2 95% CI [-0.11, 0.23] φ = 0.14	$P = 0.441$
Living with family	12 (14.63%)	6 (50.00%)	3 (25.00%)	3 (25.00%)		
English learning Enthusiasm						
High	40 (48.78%)	16 (40.00%)	15 (37.50%)	9 (22.50%)	$\chi^2 = 3.84$ df = 4 95% CI [-0.09, 0.28] φ = 0.22	$P = 0.628$
Moderate	36 (43.90%)	9 (25.00%)	13 (36.11%)	14 (38.89%)		
Low	6 (7.32%)	3 (50.00%)	2 (33.33%)	1 (16.67%)		

Note. Values are presented as frequency (percentage) for categorical variables and as mean ± SD for age. Chi-squared tests were used for categorical comparisons, and one-way ANOVA was applied to compare the mean age among groups (F(2, 79) = 0.48, $P = 0.818$). All differences were non-significant.
Effect size (φ) and 95% confidence intervals (CI) for group differences are reported.
$P < 0.05$ was considered statistically significant.

method (Flipped Classroom, Team-Based Learning, Lecture-Based) as the independent variable, and pre-test scores as a covariate. Results confirmed significant group differences ($P<0.001$), with pre-test scores as a significant predictor ($P<0.001$). Post-hoc comparisons (adjusted for the covariate) showed that the Flipped Classroom (adjusted mean = 55.2) and Team-Based Learning (adjusted mean = 50.8) outperformed the Lecture-Based group (adjusted mean = 40.1, $P<0.001$ and $P=0.005$, respectively), with no significant difference between Flipped Classroom and Team-Based Learning ($P=0.12$). These findings support the superiority of active learning methods.

Class Average Normalized Gain (CANG) was analyzed using ANOVA with Tukey post-hoc tests (Table 4), showing significant differences ($P<0.001$). As can be seen from Table 4, the one-way ANOVA test showed that there was a significant difference in CANG among different teaching models (F = 19.01, $P<0.001$). The results of the post-hoc Tukey test indicated that the flipped learning group (M = 0.28) performed significantly better than the team-based learning group (M = 0.17, $P=0.002$) and the lecture-based learning group (M = 0.07, $P<0.001$). Additionally, team-based learning group outperformed the lecture-based learning group ($P=0.015$).

Figure 2 illustrates the mean satisfaction scores of students with three different teaching methods. The highest mean satisfaction was observed in the FG method, whereas the LG method received the lowest scores. These differences highlight the influence of instructional approach on students' satisfaction.

Table 5 summarizes the comparison of total satisfaction and perspective scores among the three teaching models using the Kruskal–Wallis H test.

The highest mean score was observed in the Flipped Classroom (M = 2.58 ± 0.24), followed by TBL (M = 2.28 ± 0.27), and the lowest in the Lecture-Based group (M = 1.40 ± 0.33).

Post-hoc analysis (Bonferroni-adjusted Mann-Whitney U tests) indicated that satisfaction in the Flipped Classroom was significantly higher than both other models ($P<0.001$), and the Team-Based Learning group had moderately higher satisfaction than the Lecture-Based group ($P=0.038$). Item-level comparisons are provided in Appendix A.

Table 5. Comparison of students' satisfaction of the three teaching models

Qualitative perspectives were summarized using content analysis (Table 6) . Inter-rater agreement for the content analysis was high, with 85% agreement across 164 coding

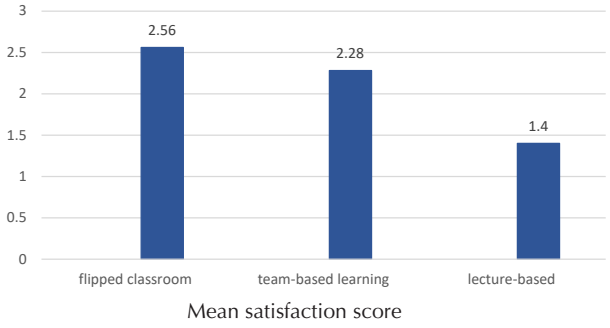

Figure 2. Mean satisfaction scores of students for three different teaching methods

Table 3. Comparative analysis of post-intervention knowledge scores across teaching models using Mixed-Effects ANCOVA controlling for pre-test covariate and team clustering

Intervention	Teaching models	Mean difference Adjusted mean (post-test)	F-value	*P* value	Post-Hoc Difference*
Before	Lecture-based classroom (a)	34.50 ± 12.63	2.04	0.136	No difference
	Flipped learning classroom (b)	40.53 ± 15.26			
	Team-based learning (c)	41.43 ± 11.92			
After (Mixed-Effects ANCOVA)	Lecture-based classroom (a)	a: 40.1 (adj)	11.23	<0.001	b > a ($P<0.001$, d = 1.22 [0.54, 1.90]) c > a ($P=0.005$, d = 0.90 [0.25, 1.55]) b = c ($P=0.12$, d = 0.37 [–0.16, 0.90])
	Flipped learning classroom (b)	b: 55.2 (adj)			
	Team-based learning (c)	c: 50.8 (adj)			

Note. Adjusted means represent estimated post-test scores after controlling for pre-test knowledge and team-level clustering in the TBL group. Analyses were performed using mixed-effects ANCOVA with teaching method as a fixed factor, pre-test score as a covariate, and team as a random effect (ICC = 0.12). Post-hoc comparisons are based on Tukey tests. Values are expressed as adjusted means unless otherwise indicated. Significance level: $P<0.05$.

Table 4. Comparison of students' knowledge using class average normalized gain (CANG)

Teaching models	Mean difference	Standard deviation	F-value	*P* value	Effect Size (η^2)	Difference
Lecture-based classroom (a)	0.07	0.083	19.01 (2/79)	$P<0.001$	$\eta^2=0.32$ 95% CI [0.15, 0.48]	b > a $P<0.001$
Flipped learning classroom (b)	0.28	0.16				b > c $P=0.002$
Team-based learning (c)	0.17	0.11				c > a $P=0.015$

Analysis conducted using one-way ANOVA to compare Class Average Normalized Gain (CANG) across groups, with Tukey HSD post-hoc tests for pairwise differences.
Effect size (η^2) reported for overall group effects, with 95% confidence intervals (CI).
$P<0.05$ considered statistically significant.

units, supporting the reliability of the coding process. The data highlights both the advantages and challenges associated with each approach, reflecting students' experiences and preferences. In the flipped classroom approach, students appreciate the flexibility to learn at their own pace and the emphasis on active participation during in-class activities. However, challenges such as self-regulation and access to technology can hinder their engagement. As seen from Table 4, team-based learning fosters collaboration and the application of theoretical knowledge, yet some students struggle with group dynamics and the anxiety related to evaluations. Finally, while the lecture-based classroom offers predictability and valuable insights from instructors, it often leads to passive learning and may not accommodate diverse learning styles.

Discussion

The aim of this study was to evaluate the effects of the three teaching approaches, including the flipped classroom, team-based learning, and lecture-based classroom in the English language education course among health sciences students with respect to their knowledge, and learning satisfaction.

The first research question was intended to investigate the effect of flipped classroom, and team-based learning on short term knowledge retention. The results provided supporting evidence for the overall effectiveness of both the flipped classroom, and team-based learning in improving the students' grammar, vocabulary, and reading achievement, with the flipped classroom demonstrating the highest efficacy. Our results corroborate previous findings on how FC, and TBL teaching approaches can enhance learning outcomes in education (38). In

Table 5. Comparison of total satisfaction and perspective scores across teaching models

Teaching model	Mean ± SD (Total Score)	Median	H (df = 2)	*P* value	Pairwise post-hoc (Bonferroni-adjusted)
Flipped Classroom (FG)	2.58 ± 0.24	2.60 [2.40 – 2.80]	22.18	<0.001	FG > LG (*P* < 0.001); FG > TBL (*P* = 0.021) TBL > LG (*P* = 0.038)
Team-Based Learning (TBL)	2.28 ± 0.27	2.25 [2.10 – 2.45]			
Lecture-Based (LG)	1.40 ± 0.33	1.40 [1.20 – 1.60]			

Note.Total satisfaction and perspective scores represent the mean of all Likert-scale items. Group differences were examined using the Kruskal-Wallis H test (H (2) = 22.18, *P* < 0.001), followed by Bonferroni-adjusted Mann-Whitney U tests (α = 0.017).Statistical significance was considered at *P* < 0.05.

Table 6. Students' perspectives of the Flipped Group (FG), Team-Based Learning (TBL), and Lecture Group (LG) teaching models with example quotes

Teaching Model			Example Quotes
Flipped classroom	Advantages	Flexibility to learn at their own pace; In-class activities focus on application and discussion, which enhances understanding; The shift from passive learner to active participation; Feel more engaged in the flipped classroom setting; Opportunities to review topics such as grammar and vocabulary before the class; Come to class prepared to discuss and apply what they learned; Flipped classroom instruction motivates them to learn.	- "I liked watching videos at home because I could pause and rewatch grammar parts I didn't understand. It made class discussions more useful." (FG Student 5) - "The in-class activities helped me apply vocabulary in real conversations, which made learning English more interesting." (FG Student 21)
	Challenges	Some students struggle with self-regulation and may not engage fully with pre-class materials; Some students had problems to have access to technology; Lack of a quiet study environment; Need to allocate time outside of class to engage with the content; Some students resist the flipped classroom and find it challenging to adapt; Some students were not able to complete pre-class assignments leading to a negative experience.	- "I found it hard to stay motivated to watch all the videos before class, especially with my busy schedule." (FG Student 16) - "Sometimes my internet was slow, so accessing the pre-class materials was frustrating." (FG Student 9)
Team-based Learning	Advantages	TBL encourages peer interaction, fostering teamwork and communication skills; Students work together to solve complex problems; TBL helps to apply theoretical knowledge to real-world situations; Individual and team accountability motivates to prepare thoroughly; The benefit of receiving diverse perspectives from peers.	- "Working in teams helped me understand vocabulary better because we discussed different meanings together." (TBL Student 1) - "I felt motivated to prepare for the RAT because I didn't want to let my team down." (TBL Student 6)
	Challenges	Some students cannot thrive in group settings; conflicts or free-riders can arise; TBL requires substantial in-class time for team discussions and activities; Aligning individual and team assessments can be challenging; The experience of anxiety related to evaluations.	- "Some team members didn't contribute much, which made group work stressful." (TBL Student 17) - "The TRAT made me nervous because I wasn't sure if my answers were correct." (TBL Student 23)
Lecture-based classroom	Advantages	Some students appreciate the predictability of lecture-based formats; The insights elucidated by the teacher which may not be available in textbooks is valuable; Students have preferences to learn from a knowledgeable teacher; Lecture helps to develop skills such as note-taking and summarizing key points.	- "The teacher's explanations of grammar rules were clear and easy to follow, which helped me take good notes." (LG Student 13) - "I liked the structure of lectures because I knew what to expect each class." (LG Student 22)
	Challenges	Lectures can lead to passive absorption without active engagement; Students may forget information quickly after a lecture; Lectures may not cater to all learning preferences; Difficulty in retaining information presented in lectures; Lectures provide few opportunities for interaction; Feedback is often neglected in the learning process.	- "I often forgot the vocabulary from lectures because we didn't practice it actively in class." (LG Student 3) - "There wasn't much chance to discuss or ask questions, so I felt disconnected from the material." (LG Student14)

alignment with previous research in the domain of English language education, our findings corroborate the effectiveness of FC, and TBL approaches in enhancing the English proficiency of EFL students, surpassing the outcomes associated with traditional lecture-based, teacher-centered instructional approaches (13,39). These results are consistent with the conclusions drawn from our study. Evidence highlights that active teaching models can foster more interaction among learners, elevate lifelong learning skills, and erode the passivity of students in the classroom (9). Proficiency in the English language by the adaptation of active teaching methods is considered as a crucial component for students to succeed academically, as it allows them to access current, field-specific technical and theoretical knowledge more effectively (5).

One reason for the noticeable differences in students' knowledge comparing the pretest and posttest scores in the FC, and TBL groups in comparison to the LG is the type of higher-level cognitive tasks and activities carried out in both the flipped classroom, and team-based learning. Moreover, the use of diverse pre-learning resources can facilitate learners' engagement in self-directed learning (35). It is noted that the FC, and TBL does not merely involve the acquisition of knowledge outside the classroom. Rather, they involve pre-class preparation for active participation and team learning in nurturing active learners, who can perform high level cognitive work (40). In the FC, and TBL teaching approaches, instructors meticulously design the course structure to ensure a coherent progression of learning experiences. This includes the integration of pre-class online materials, in-class activities, and post-class reflective content. Such an approach facilitates student engagement in meaningful learning activities and fosters favorable attitudes towards educational outcomes (41). Furthermore, the classroom activities conducted within the frameworks of FC, and TBL, including group discussions and paired collaborations, facilitated an increased engagement of students in higher-order cognitive processes such as analysis and evaluation. Consequently, these approaches fostered the development of students' critical and creative thinking skills, thereby equipping them to effectively address challenges related to target grammar, vocabulary, and reading comprehension. In a similar vein, the pre-class study materials, which included instructional videos and PowerPoint presentations provided to students in both the FC, and TBL groups, facilitated critical thinking and information analysis prior to class. This approach enabled students to evaluate various pieces of information, categorize them, troubleshoot for solutions, and enhance their understanding of English grammar, vocabulary, and reading comprehension. This rationale aligns with the assertions made by Herreid and Schiller (42), as well as Silberman (43), who argue that higher-order thinking can be fostered through the implementation of flipped classroom and TBL approaches. These strategies encourage students to take responsibility for their learning by frequently reviewing pre-class materials and engaging in discussions about the content during class sessions. The findings are also in line with, Nederveld and Berge's (44), contention that instructors can use class time to focus on application and higher-level learning rather than lecturing and other lower-level thinking tasks. The markedly higher posttest scores recorded in the FC as opposed to TBL can be ascribed to the FC's design, which facilitates active engagement through peer instruction during in-class activities. In contrast, while TBL does incorporate collaborative elements, its dependence on immediate assessments, such as the IRAT and, TRAT may not foster the same level of comprehension prior to interaction with the material in the classroom. Therefore, the flipped classroom's focus on preparatory learning and active participation is likely a significant factor contributing to the enhanced knowledge retention observed in this instructional approach.

The second research question was intended to investigate the learning satisfaction of flipped classroom, and team-based learning approaches. Findings revealed that students reported more positive learning satisfaction for FC, and TBL in comparison to LG members. The FC, and TBL teaching approaches are characterized by their student-centered nature, distinguishing them from conventional classroom settings that predominantly emphasize instructor-led instruction and offer predominantly unidirectional learning resources. Previous research indicates that discussions centered on learners, along with facilitative behaviors exhibited by instructors during learning activities, contribute to participants feeling acknowledged and appreciated within the educational environment (45,46). Moreover, students have the opportunity to transcend the conventional limitations of classroom instruction and independently attain their educational objectives both within and beyond the classroom environment. Specifically, the advance provision of video lectures, and PowerPoint presentations, which constitute a facet of pre-class activities, afford students a flexible framework that empower them to determine the timing, location, and methods of their study in alignment with their individual learning preferences. This approach facilitates self-directed learning, encourages the utilization of familiar learning tools, and enhances their positive perception of the flipped classroom, and team-based learning approaches. It is important to note that the perception of increased time commitment in FC and TBL may reflect the initial adjustment period required for students to adapt to these more interactive formats, as they often demand more preparatory work outside of class. Additionally, the higher burden and pressure associated with lecture-based instruction can be explained by its passive nature, which often leaves students

feeling overwhelmed with content without the benefit of interactive support (47).

The qualitative data collected to address the third research question regarding the students' perspectives about their learning experience with flipped classroom, team-based learning, and lecture-based classroom revealed two main themes as advantages, and challenges of each teaching approach. Flipped classrooms offered significant benefits, such as fostering active engagement and allowing students to learn at their own pace, which aligns with the principles of constructivist learning theories that emphasize active participation in knowledge construction (48). However, challenges such as self-regulation and access to technology underscore the need for supportive structures to facilitate effective learning in this model (49). In contrast, team-based learning promotes collaboration and accountability, enhancing communication skills and providing diverse perspectives, consistent with research that emphasizes the importance of social interaction in learning (10). Nonetheless, issues like group dynamics and anxiety related to evaluations can hinder the effectiveness of TBL, suggesting that instructors must carefully manage team processes to mitigate these challenges (50). Lastly, while lecture-based formats provide structure and valuable insights from knowledgeable instructors, they often lead to passive learning experiences and limited interaction, which can adversely affect information retention (51,52). This highlights the necessity for educators to balance content delivery with opportunities for engagement, ensuring that all learning preferences are accommodated.

This study has its own limitations. Firstly, although random allocation was performed using a lottery method to minimize selection bias, the quasi-experimental design conducted within a single institution may still be subject to unmeasured confounders (e.g., institutional context, student motivation), potentially limiting the generalizability of findings to broader populations. Moreover, the convenience sampling ($n = 82$) increases type II error risk for detecting small effects ($\beta \approx 0.20$ for $f = 0.25$), limiting generalizability; future multi-site RCTs with powered samples are recommended. Additionally, while parallel forms minimized practice and recall effects, subtle form differences could influence scores; future studies should use fully counterbalanced designs. Moreover, the reliance on self-reported measures for assessing student satisfaction may result in response bias, as participants might provide socially desirable responses rather than their authentic sentiments. Additionally, the study was conducted within a single institution, which may limit the applicability of the findings to other educational environments or contexts. Lastly, the research did not consider potential confounding variables, such as individual differences in learning styles, which could significantly affect the outcomes.

Future investigations should consider the implementation of a randomized controlled trial design to improve the validity of the results and reduce the potential for selection bias. Additionally, increasing the sample size and incorporating multiple institutions would contribute to a more thorough understanding of the efficacy of the teaching approaches across various educational contexts. By the same token, future research could certainly explore the inclusion of writing components to provide a more comprehensive evaluation of English language proficiency, encompassing both receptive and productive skills.

Conclusion

This study demonstrates that both the flipped classroom and team-based learning approaches significantly improve knowledge, and student satisfaction compared to traditional lecture-based instruction. By fostering active participation, these innovative teaching models create a more engaging educational environment. The results highlight the need for medical education to adopt such approaches to better prepare students for their future careers, ultimately leading to improved proficiency in essential skills like English language competency in the medical field.

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Competing Interests

None.

Ethical Approval

Informed oral consent was granted from all participants and the research protocol received ethical approval from the ethics committee of Kerman University of Medical Sciences (IR.KMU.REC.1403.177).

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Appendix A. Comparison of students' satisfaction of the three teaching models

Items	Groups	Strongly agree/agree	Neutral	Strongly disagree/ disagree	Statistics (H, df)	*P* value	Effect Size (ε^2)	Post-hoc Pairwise (Mann-Whitney U, Bonferroni-adjusted)	*P* value
I enjoyed the learning experience	FG*	15 (53.50%)	3 (10.70%)	10 (35.80%)	H=3.05 df=2	0.217	ε^2=0.04 95% CI [0.00, 0.12]	TBL-LG	No difference
	TBL**	8 (26.67%)	10 (33.33%)	12 (40.00%)				LG-FG	
	LG***	3 (12.50%)	13 (54.17%)	8 (33.33%)				TBL-FG	
I like to repeat the learning experience	FG	20 (71.43%)	0 (0.00%)	8 (28.57%)	H=17.48 df=2	<0.001	ε^2=0.21 95% CI [0.09, 0.34]	TBL-LG	*P*=0.066 [0.02, 0.31]
	TBL	6 (20.00%)	8 (26.67%)	16 (53.33%)				LG-FG	*P*<0.001 [0.45, 0.78]
	LG	3 (12.50%)	3 (12.50%)	18 (75.00%)				TBL-FG	*P*=0.009 [0.12, 0.45]
I like this teaching approach	FG	24 (85.72%)	2 (7.14%)	2 (7.14%)	H=32.13 df=2	<0.001	ε^2=0.39 95% CI [0.22, 0.55]	TBL-LG	*P*=0.006 [0.18, 0.52] LG-FG: TBL-FG:
	TBL	12 (40.00%)	13 (43.33%)	5 (16.67%)				LG-FG	*P*<0.001 [0.65, 0.92]
	LG	2 (8.33%)	8 (33.33%)	14 (58.34%)				TBL-FG	*P*=0.017 [0.08, 0.41]
I was able to establish a good rapport with classmates	FG	19 (67.86%)	6 (21.43%)	3 (10.71%)	H=24.26 df=2	<0.001	ε^2=0.30, 95% CI [0.15, 0.45]	TBL-LG	*P*=0.001 [0.22, 0.56]
	TBL	16 (53.34%)	7 (23.33%)	7 (23.33%)				LG-FG	*P*<0.001 [0.58, 0.85]
	LG	2 (8.33%)	6 (25.00%)	16 (66.67%)				TBL-FG	*P*=0.705 [-0.05, 0.28]
This course takes a lot of my time	FG	15 (53.57%)	9 (32.14%)	4 (14.29%)	H=25.67 df=2	<0.001	ε^2=0.31 95% CI [0.16, 0.47]	TBL-LG	*P*=0.001 [0.25, 0.59]
	TBL	11 (36.67%)	9 (30.00%)	10 (33.33%)				LG-FG	*P*<0.001 [0.60, 0.87]
	LG	1 (4.17%)	3 (12.50%)	20 (83.33%)				TBL-FG	*P*=0.338 [-0.02, 0.31]
This course gives me too much burden and pressure	FG	2 (7.14%)	5 (17.86%)	21 (75.00%)	H=25.49 df=2	<0.001	ε^2=0.31 95% CI [0.16, 0.46]	TBL-LG	*P*=0.001 [0.24, 0.58]
	TBL	7 (23.33%)	5 (16.67%)	18 (60.00%)				LG-FG	*P*<0.001 [0.61, 0.88]
	LG	18 (75.00%)	2 (8.33%)	4 (16.67%)				TBL-FG	*P*=0.594 [-0.04, 0.29]
This course improves learning outcomes	FG	24 (85.72%)	2 (7.14%)	2 (7.14%)	H=34.00 df=2	<0.001	ε^2=0.41 95% CI [0.25, 0.57]	TBL-LG	*P*<0.001 [0.35, 0.68]
	TBL	20 (66.66%)	5 (16.67%)	5 (16.67%)				LG-FG	*P*<0.001 [0.70, 0.95]
	LG	3 (12.50%)	3 (12.50%)	18 (75.00%)				TBL-FG	*P*=0.599 [-0.03, 0.30]
This course helps me study more deeply	FG	23 (82.14%)	3 (10.72%)	2 (7.14%)	H=40.54 df=2	<0.001	ε^2=0.49 95% CI [0.33, 0.65]	TBL-LG	*P*<0.001 [0.42, 0.74]
	TBL	19 (63.34%)	4 (13.33%)	7 (23.33%)				LG-FG	*P*<0.001 [0.75, 0.98]
	LG	0 (0.00%)	5 (20.83%)	19 (79.17%)				TBL-FG	*P*=0.429 [-0.01, 0.32]
This course is beneficial to me	FG	15 (53.57%)	7 (25.00%)	6 (21.43%)	H=20.86 df=2	<0.001	ε^2=0.25 95% CI [0.11, 0.40]	TBL-LG	*P*<0.001 [0.28, 0.62]
	TBL	17 (56.67%)	6 (20.00%)	7 (23.33%)				LG-FG	*P*<0.001 [0.63, 0.90]
	LG	2 (8.33%)	4 (16.67%)	18 (75.00%)				TBL-FG	*P*=1.00 [-0.06, 0.27]
This course improves my learning motivation	FG	24 (85.72%)	2 (7.14%)	2 (7.14%)	H=46.08 df=2	<0.001	ε^2=0.56 95% CI [0.41, 0.71]	TBL-LG	*P*=0.001 [0.30, 0.64]
	TBL	22 (73.33%)	5 (16.67%)	3 (10.00%)				LG-FG	*P*<0.001 [0.72, 0.97]
	LG	1 (4.16%)	3 (12.50%)	20 (83.34%)				TBL-FG	*P*=1.00 [-0.05, 0.28]
I recommend this course to other students	FG	22 (78.57%)	1 (3.57%)	5 (17.86%)	H=19.02 df=2	<0.001	ε^2=0.23, 95% CI [0.10, 0.37]	TBL-LG	*P*<0.001 [0.27, 0.61]
	TBL	21 (70.00%)	5 (16.67%)	4 (13.33%)				LG-FG	*P*<0.001 [0.62, 0.89]
	LG	6 (25.00%)	3 (12.50%)	15 (62.50%)				TBL-FG	*P*=1.00 [-0.06, 0.27]
I am satisfied with the course	FG	22 (78.57%)	5 (17.86%)	1 (3.57%)	H=30.20 df=2	<0.001	ε^2=0.37 95% CI [0.21, 0.53]	TBL-LG	*P*<0.001 [0.33, 0.67]
	TBL	22 (73.33%)	3 (10.00%)	5 (16.67%)				LG-FG	*P*<0.001 [0.68, 0.94]
	LG	4 (16.67%)	3 (12.50%)	17 (70.83%)				TBL-FG	*P*=1.00 [-0.05, 0.28]

*FG: Flipped group; **TBL: Team-based learning; ***LG: Lecture group

Analysis conducted using Kruskal-Wallis H test for overall group differences, followed by Mann-Whitney U tests with Bonferroni correction (α=0.017) for pairwise comparisons. Effect size (ε^2) reported for overall group effects, with 95% confidence intervals (CI) approximated via chi-square. *P*<0.05 considered statistically significant for Kruskal-Wallis; α=0.017 for post-hoc Mann-Whitney U tests.