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IMPLEMENTATION OF STRUCTURED CASE-BASED LEARNING (CBL) MODULES IN PHYSIOLOGY FOR ENHANCED CLINICAL INTEGRATION IN FIRST-YEAR MBBS STUDENTS

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ABSTRACT

Background: Physiology provides the foundation for clinical understanding, but first-year MBBS students may find it difficult to apply theoretical concepts to clinical situations. Case-Based Learning (CBL) offers an approach to connect basic physiological mechanisms with clinical problems. This study aimed to implement structured CBL modules and assess changes in students' learning and perceptions of students and faculty.

Materials and Methods: A single-group, pre-test–post-test educational intervention was conducted over six months among first-year MBBS students. Eight structured CBL modules were implemented alongside conventional teaching. Of 100 enrolled students, 88 completed both assessments and were included in the paired analysis. Learning outcomes were assessed using 80 multiple-choice questions. Student and faculty perceptions were evaluated using structured questionnaires. Pre-test and post-test scores were compared using the paired t-test.

Results: The mean score increased from 43.58 ± 8.64 in the pre-test to 66.89 ± 8.30 in the post-test, with a mean improvement of 23.31 ± 2.03 marks ($P < 0.001$). Significant improvements were observed across all eight modules. After the intervention, 65 students (73.86%) achieved the very good knowledge category. Mean student and faculty perception scores were 46.31 ± 1.76 out of 50 and 36.50 ± 1.29 out of 40, respectively.

Conclusion: Structured CBL was associated with improved assessment scores and favourable perceptions among students and faculty. It may supplement conventional Physiology teaching, although controlled studies are needed to establish its independent effectiveness.

KEYWORDS: Case-Based Learning; Clinical Integration; Competency-Based Medical Education; Medical Education; Physiology; Undergraduate Medical Students.

1. INTRODUCTION

Physiology provides an understanding of normal body functions and homeostasis, forming an important foundation for medical education. However, first-year MBBS students often find it difficult to relate physiological concepts to clinical conditions. Conventional lectures cover the prescribed syllabus but may offer limited opportunities to apply this knowledge in clinical situations. This has encouraged the use of teaching approaches that involve students more actively. Hudson and Buckley evaluated case-based teaching and reported its continuing educational benefits. [1]

Case-Based Learning (CBL) uses clinical scenarios to encourage students to identify relevant findings, discuss underlying mechanisms, and apply previously acquired knowledge. Unlike conventional lectures, CBL provides opportunities for guided reasoning and discussion. Srinivasan et al. compared problem-based and case-based learning following a curricular shift and examined students' knowledge and attitudes. [2] Gade and Chari studied CBL in endocrine Physiology, focusing on self-directed learning and the development of soft skills among medical students. [3]

CBL may be particularly relevant during preclinical training, when students are beginning to connect physiological mechanisms with clinical findings. For example, a case involving dehydration can bring together renal water conservation, fluid compartments, and hormonal regulation. Ghosh examined students' perceptions of combining lectures with case-oriented problem-solving tutorials. [4] Bansal and Goyal also evaluated the effectiveness of CBL in Physiology teaching. [5] The organisation of CBL sessions is another important consideration. Merely presenting a clinical case may not be sufficient unless students are given clear learning objectives, opportunities for discussion, and appropriate faculty guidance. Structured modules allow teachers to select clinical problems that correspond with the topics being taught and assess students' understanding afterwards. Muthukrishnan et al. described the planning, implementation, and evaluation of multicomponent CBL among first-year Indian medical undergraduates. [6] Nayak et al. examined a case-based readiness assurance process involving collaborative learning in Physiology. [7] These approaches suggest that the educational value of CBL depends not only on the cases selected but also on how the sessions are conducted.

With the introduction of Competency-Based Medical Education in India, greater attention has been given to the application of basic medical sciences, early clinical exposure, and active participation in learning. CBL may be useful in this setting

because clinical problems can be introduced while students are still developing their foundational knowledge. Kumar et al. compared CBL with flipped classroom teaching for the clinical and applied aspects of Physiology under the competency-based undergraduate curriculum. [8] Bhattacharya et al. also evaluated the effect of CBL on cognitive domain scores in reproductive physiology among first-year medical students. [9] Findings from related subjects have further encouraged the use of clinical cases in undergraduate teaching. Nair et al. studied CBL for improving the understanding of Biochemistry, while Vora and Shah explored its application in Pharmacology. [10,11]

Clinical integration during the first year does not necessarily require extensive exposure to hospital-based teaching. Carefully selected clinical scenarios can introduce students to the relevance of physiological mechanisms while remaining appropriate to their existing knowledge. Sathishkumar et al. examined medical students' attitudes towards early clinical exposure in endocrine physiology. [12] Dehghan et al. subsequently studied an early clinical exposure programme in renal physiology. [13] More recently, Ambike et al. investigated the implementation of CBL among first-year MBBS students in Indian medical colleges. [14] These studies provide a basis for considering how clinically oriented teaching can be incorporated into regular preclinical instruction.

Despite the growing use of CBL, its implementation requires suitable case preparation, faculty involvement, and time within the existing teaching schedule. It is also important to examine whether students demonstrate measurable changes in knowledge after participating in structured sessions and how both learners and teachers perceive the method. Therefore, the present study aimed to implement structured Case-Based Learning modules in Physiology to enhance clinical integration among first-year MBBS students. The objectives were to assess changes in students' learning through pre-test and post-test scores and to evaluate students' and faculty perceptions regarding the CBL sessions.

MATERIAL AND METHODS

Study Design and Setting

The present study was a single-center, mixed-method educational intervention conducted in the Department of Physiology at an autonomous state medical college in Sultanpur, Uttar Pradesh, India, over six months. Structured Case-Based Learning (CBL) modules were introduced alongside routine teaching to assess changes in students' learning and their ability to apply physiological concepts to clinical situations. The study included pre-test and post-test assessments, along with feedback from students and faculty members.

Study Participants

The study population comprised first-year Bachelor of Medicine and Bachelor of Surgery (MBBS) students attending Physiology classes during the study period. A total of 100 students were enrolled. Students who were willing to participate and available for both assessments were eligible for the paired analysis. Those who declined participation, missed major CBL sessions, or did not complete both assessments were excluded from the final paired comparison. Of the 100 enrolled students, 88 completed both the pre-test and post-test and were included in the analysis.

Preparation and Implementation of CBL Modules

Eight structured CBL modules were developed to integrate physiological principles with commonly encountered clinical conditions. The topics included hemorrhage and blood pressure regulation, bronchial asthma and pulmonary function, anemia and oxygen transport, dehydration and renal water balance, diabetes mellitus and glucose homeostasis, thyroid disorders and metabolic regulation, peptic ulcer and gastric secretion, and congestive heart failure and compensatory mechanisms.

Four faculty members involved in undergraduate Physiology teaching served as facilitators. Before implementation, they attended a departmental orientation covering case preparation, small-group facilitation, guided discussion, debriefing, and assessment procedures. The modules were reviewed by senior faculty members to ensure their suitability for first-year MBBS students.

Students were introduced to the objectives and procedures of CBL before the intervention. A baseline assessment was conducted to evaluate their existing knowledge. Subsequently, eight CBL sessions were organised in small groups at regular intervals. Each session involved presentation of a clinical case, identification of relevant physiological concepts, guided discussion, problem-solving, and faculty facilitation. Debriefing was conducted at the end of each session to reinforce important concepts and address students' doubts. Conventional teaching continued during the study period.

Assessment of Learning Outcomes

Students' learning was evaluated using multiple-choice question (MCQ)-based pre-test and post-test assessments. The assessment covered all eight modules, with 10 MCQs allocated to each module, making a total of 80 questions and a maximum possible score of 80 marks.

The pre-test was administered before the CBL intervention, while the post-test was conducted after completion of all eight sessions. Individual scores were recorded separately for each assessment. Overall and module-wise scores were compared to determine changes in knowledge following CBL. Students were also classified into four knowledge categories based on their percentage scores: poor (less than 50%), average (50–59%), good (60–79%), and very good (80% or above).

Assessment of Student and Faculty Perceptions

Following the intervention, students' perceptions were assessed using a structured questionnaire containing 10 statements related to conceptual understanding, clinical application, active participation, relevance of cases, retention, faculty facilitation, and inclusion of CBL in regular teaching. Responses were recorded on a five-point Likert scale ranging from strongly disagree (1) to strongly agree (5). The maximum possible total score was 50.

Feedback was also obtained from the four faculty facilitators using a structured questionnaire consisting of 10 statements. These assessed clinical integration, student participation, problem-solving, suitability of cases, feasibility, preparation requirements, and continuation of CBL in future batches. Responses were recorded on a four-point Likert scale, with a maximum total score of 40.

Statistical Analysis

Data obtained from the assessments and feedback questionnaires were analysed using descriptive and inferential statistics. Categorical variables were presented as frequencies and percentages, while continuous variables were expressed as mean ± standard deviation (SD). Overall and module-wise pre-test and post-test scores were compared using the paired Student's t-test, as the same students underwent both assessments. Changes in scores were also expressed as percentages of the maximum possible marks. Student and faculty perception scores were summarised using means, standard deviations, and percentages. A P value below 0.05 was considered statistically significant.

Ethical Considerations

The study was conducted after obtaining approval from the Institutional Ethics Committee of T.S. Misra Medical College & Hospital, Lucknow, Uttar Pradesh, India. Written informed consent was obtained from the participating students before enrolment. Participation was voluntary, and confidentiality of individual assessment scores and feedback responses was maintained throughout the study.

RESULTS

A total of 100 first-year MBBS students were enrolled in the study, of whom 88 (88.00%) completed both the pre-test and post-test assessments and were included in the final paired analysis. Among these, 53 were male and 35 were female. The mean pre-test score was 43.58 ± 8.64, which increased to 66.89 ± 8.30 following the structured Case-Based Learning (CBL) sessions. The mean improvement was 23.31 ± 2.03 marks, corresponding to 29.13% of the maximum possible score. This difference was statistically significant (paired t-test, t = 107.67, df = 87, P < 0.001) (Table 1).

Table 1. Comparison of Overall Pre-test and Post-test Scores Among Students (n = 88)

Assessment	Mean ± SD	Median	Range	Score (% of 80)
Pre-test	43.58 ± 8.64	45	16–57	54.47
Post-test	66.89 ± 8.30	68	40–79	83.61
Paired improvement	23.31 ± 2.03	23	20–26	29.13
Values are reproduced as reported. The improvement percentage is the gain expressed as a percentage of the maximum possible 80 marks (equivalent to 29.13 percentage points). Paired t-test: t = 107.67, df = 87, P < 0.001. Of the 88 students, 53 were male and 35 were female. SD = standard deviation.				

The distribution of students across knowledge categories also changed following the intervention. Before CBL, 21 students (23.86%) belonged to the poor category, 36 (40.91%) to the average category, and 31 (35.23%) to the good category. None were classified as very good. After CBL, 65 students (73.86%) were classified as very good, 19 (21.59%) as good, and four (4.55%) as average. No student remained in the poor category (Figure 1).

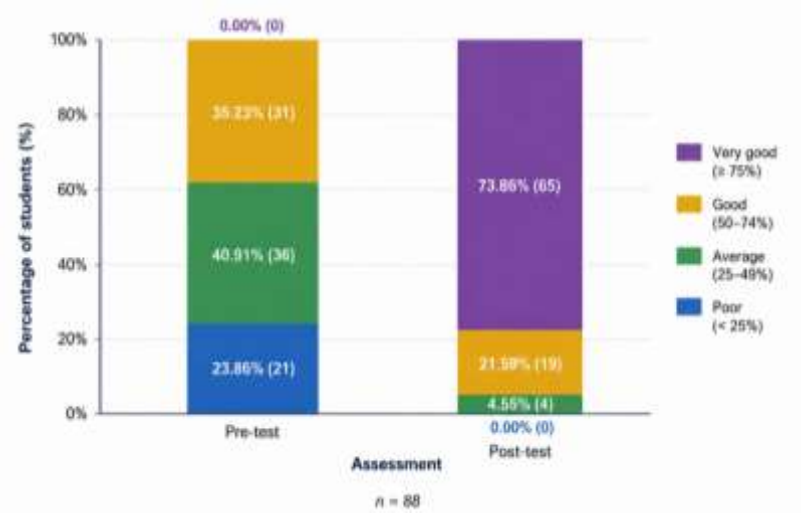


Figure 1. Distribution of students according to knowledge score categories in pre-test and post-test

Module-wise analysis showed statistically significant improvements in all eight CBL modules (P < 0.001 for each module). The greatest improvement was observed in Diabetes Mellitus and Glucose Homeostasis (35.91%), followed by

Anemia and Oxygen Transport (33.98%), Dehydration and Renal Water Balance (31.70%), and Thyroid Disorder and Metabolic Regulation (31.48%). The smallest improvement was recorded in Bronchial Asthma and Pulmonary Function (16.70%). Improvements were observed across all the physiological systems included in the intervention (Table 2).

Table 2. Module-wise Comparison of Pre-test and Post-test Scores Following CBL (n = 88)

Physiology module	Pre-test mean ± SD	Post-test mean ± SD	Mean paired improvement ± SD	P value
Hemorrhage and Regulation of Blood Pressure	5.40 ± 1.94	8.20 ± 1.52	2.81 ± 1.79	<0.001
Bronchial Asthma and Pulmonary Function	5.68 ± 1.91	7.35 ± 1.67	1.67 ± 1.99	<0.001
Anemia and Oxygen Transport	5.42 ± 1.54	8.82 ± 1.59	3.40 ± 1.78	<0.001
Dehydration and Renal Water Balance	5.40 ± 1.52	8.57 ± 1.61	3.17 ± 1.76	<0.001
Diabetes Mellitus and Glucose Homeostasis	5.47 ± 1.91	9.06 ± 1.61	3.59 ± 1.75	<0.001
Thyroid Disorder and Metabolic Regulation	5.59 ± 1.59	8.74 ± 1.64	3.15 ± 1.73	<0.001
Peptic Ulcer and Gastric Secretion	5.25 ± 1.83	8.02 ± 1.76	2.77 ± 1.73	<0.001
Congestive Heart Failure and Compensatory Mechanisms	5.38 ± 1.89	7.72 ± 1.68	2.34 ± 1.90	<0.001
Each module contained 10 multiple-choice questions (maximum score: 10). Paired t-test was reported for each module. SD = standard deviation; CBL = case-based learning. The reported module-wise means should be reconciled with the overall results before submission.				

Students reported favourable perceptions of the CBL sessions. The overall mean perception score was 46.31 ± 1.76 out of 50, corresponding to 92.61 ± 3.53% of the maximum possible score. Most students agreed or strongly agreed that CBL improved their understanding of Physiology, helped them apply physiological concepts to clinical situations, and encouraged participation. Clinical correlation was positively rated by 84 students (95.45%), while 86 (97.73%) supported the regular inclusion of CBL in Physiology teaching. No student selected a disagreement response for any questionnaire item (Table 3).

Table 3. Students' Perceptions of Structured Case-Based Learning Sessions (n = 88)

Perception statement	Strongly agree, n (%)	Agree, n (%)	Neutral, n (%)	Mean ± SD
CBL sessions helped me to understand Physiology concepts better.	62 (70.45)	23 (26.14)	3 (3.41)	4.67 ± 0.54
CBL improved my ability to apply Physiology knowledge in clinical situations.	65 (73.86)	18 (20.45)	5 (5.68)	4.68 ± 0.58
CBL sessions made learning more interesting than routine lecture-based teaching.	54 (61.36)	31 (35.23)	3 (3.41)	4.58 ± 0.56
CBL encouraged active participation and discussion.	51 (57.95)	29 (32.95)	8 (9.09)	4.49 ± 0.66
CBL helped me to correlate basic science with clinical problems.	66 (75.00)	18 (20.45)	4 (4.55)	4.70 ± 0.55
The cases used in CBL were relevant to first-year MBBS level.	56 (63.64)	27 (30.68)	5 (5.68)	4.58 ± 0.60
The time allotted for CBL sessions was adequate.	60 (68.18)	23 (26.14)	5 (5.68)	4.62 ± 0.59
The facilitator/teacher guided the session effectively.	64 (72.73)	21 (23.86)	3 (3.41)	4.69 ± 0.53
CBL helped me in better retention of the topic.	57 (64.77)	25 (28.41)	6 (6.82)	4.58 ± 0.62
CBL should be included regularly in Physiology teaching.	64 (72.73)	22 (25.00)	2 (2.27)	4.70 ± 0.51
Five-point Likert scale: 5 = strongly agree, 4 = agree, 3 = neutral, 2 = disagree, 1 = strongly disagree. No student selected disagree or strongly disagree for any item. Overall student perception score: 46.31 ± 1.76 out of 50; mean percentage score: 92.61 ± 3.53%. SD = standard deviation; CBL = case-based learning.				

Faculty feedback was similarly favourable. The four faculty members reported an overall mean perception score of 36.50 ± 1.29 out of 40, equivalent to 91.25 ± 3.23% of the maximum possible score. All four agreed or strongly agreed that CBL improved clinical integration, encouraged participation and problem-solving, and should be continued in future batches. However, all faculty members also agreed that CBL required more preparation than routine teaching (Table 4).

Table 4. Faculty Perceptions of Structured Case-Based Learning Sessions (n = 4)

Perception statement	Strongly agree, n (%)	Agree, n (%)	Mean ± SD
CBL was useful for improving clinical integration in Physiology.	3 (75.00)	1 (25.00)	3.75 ± 0.50
Students showed better participation during CBL sessions.	3 (75.00)	1 (25.00)	3.75 ± 0.50
CBL encouraged problem-solving and reasoning among students.	3 (75.00)	1 (25.00)	3.75 ± 0.50
The cases were suitable for first-year MBBS students.	3 (75.00)	1 (25.00)	3.75 ± 0.50
CBL was feasible to conduct within available teaching time.	1 (25.00)	3 (75.00)	3.25 ± 0.50
CBL required more preparation compared to routine teaching.	2 (50.00)	2 (50.00)	3.50 ± 0.58
CBL can be incorporated in regular Physiology teaching schedule.	3 (75.00)	1 (25.00)	3.75 ± 0.50
CBL helped in identifying students' conceptual difficulties.	2 (50.00)	2 (50.00)	3.50 ± 0.58
Student response during CBL was satisfactory.	3 (75.00)	1 (25.00)	3.75 ± 0.50
CBL should be continued in future batches.	3 (75.00)	1 (25.00)	3.75 ± 0.50
Four-point Likert scale: 4 = strongly agree, 3 = agree, 2 = disagree, 1 = strongly disagree. No faculty member selected disagree or strongly disagree for any item. Overall faculty perception score: 36.50 ± 1.29 out of 40; mean percentage score: 91.25 ± 3.23%. SD = standard deviation; CBL = case-based learning.			

Discussion

The present study examined changes in learning scores and perceptions following the implementation of structured Case-Based Learning (CBL) modules among first-year MBBS students. A significant improvement was observed in overall assessment scores, with favourable responses from both students and faculty members. The mean score increased from 43.58 ± 8.64 before the intervention to 66.89 ± 8.30 after completion of eight CBL modules ($P < 0.001$). Bansal and Goyal also reported a significant improvement in pre-test and post-test scores after introducing CBL in Physiology among first-year medical students. [5] Muthukrishnan et al. evaluated multicomponent CBL among first-year Indian medical undergraduates and reported encouraging educational outcomes. [6] More recently, Majeed and Usmani observed improved post-test performance following case-based Physiology teaching, although their study compared flipped classroom teaching with interactive lectures. [15] These findings support the use of clinically oriented teaching activities during the preclinical years.

Apart from the improvement in mean scores, a noticeable change was observed in the distribution of students across knowledge categories. Before the intervention, 21 students (23.86%) were classified as having poor knowledge, while none belonged to the very good category. Following CBL, 65 students (73.86%) were classified as very good, and no student remained in the poor category. This suggests improvement across the assessed student group rather than only a change in the overall mean. Similar improvements in cognitive assessment scores following CBL have been reported by Bhattacharya et al. in reproductive physiology among first-year medical students. [9] However, the absence of a control group in the present study prevents the observed improvement from being attributed solely to CBL.

Module-wise assessment showed significant increases in scores across all eight physiological topics. The greatest improvement was observed in Diabetes Mellitus and Glucose Homeostasis (35.91 percentage points), followed by Anemia and Oxygen Transport (33.98 percentage points) and Dehydration and Renal Water Balance (31.70 percentage points). Bronchial Asthma and Pulmonary Function showed the smallest improvement (16.70 percentage points), although the increase was statistically significant. Gade and Chari explored the use of CBL in endocrine physiology and highlighted its usefulness in encouraging self-directed learning. [3] Nayak et al. also examined collaborative case-based learning in Physiology through a structured readiness assurance process. [7] Differences between modules in the present study may reflect variations in topic complexity, students' previous knowledge, or the suitability of individual cases. These explanations remain tentative, as the study did not investigate the factors responsible for module-wise differences.

Student feedback was largely favourable, with an overall mean perception score of 46.31 ± 1.76 out of 50. Most participants agreed that CBL helped them understand physiological concepts, relate basic science to clinical conditions, and participate in discussions. Rehan et al. examined students' perceptions of different Physiology teaching methods and reported the educational value of interactive approaches, including case-based lectures. [16] Holland and Pawlikowska found that students valued opportunities for case discussion with faculty while comparing facilitated small-group learning with electronic learning resources in Anatomy. [17] Mamakli et al. also reported favourable learner satisfaction and engagement in a scenario-based educational intervention. [18] Although the teaching formats differed, these observations are consistent with the positive student responses recorded in the present study.

Clinical relevance was an important component of student feedback. A total of 84 students (95.45%) agreed or strongly agreed that CBL helped them correlate basic science concepts with clinical problems. Similarly, 86 students (97.73%) supported its regular inclusion in Physiology teaching. In a qualitative study conducted in a resource-limited setting, Uqaili et al. found that students valued CBL for conceptual clarity, participation, and early clinical reasoning, while also identifying challenges related to time and facilitation. [19] The present findings reflect perceived improvement in clinical application. However, this was assessed through questionnaire responses rather than direct observation of clinical reasoning or performance in patient-care settings.

Faculty perceptions were also positive, with a mean score of 36.50 ± 1.29 out of 40. All four facilitators supported the continuation of CBL in future batches and considered it useful for student participation and clinical integration. At the

same time, they agreed that preparing CBL sessions required additional effort compared with routine teaching. Delany et al., in a qualitative study exploring faculty experiences of implementing CBL, examined the practical and educational demands associated with this teaching approach. [20] The present findings suggest that faculty orientation and preparation of suitable cases are important considerations when introducing CBL into an existing teaching schedule. However, opinions from only four faculty members cannot represent the wider teaching community.

Linking clinical situations with basic physiological mechanisms may help students appreciate the relevance of subjects taught before clinical postings. Waliany et al. evaluated prospective case-based teaching among preclinical students and reported improvements in selected self-assessed aspects of clinical reasoning compared with nonparticipants. [21] Dickinson et al. involved a real patient in case development and teaching, with students reporting greater engagement and improved application of basic science concepts to clinical material. [22] These studies indicate different ways of introducing clinically relevant learning during the early years of medical education. The present study adds evidence from a structured eight-module intervention in first-year Physiology, combining assessment scores with feedback from both learners and facilitators.

Strengths and Limitations

A strength of the present study was the implementation of eight structured modules covering different physiological systems, with paired assessments completed by 88 students. Student and faculty feedback provided additional information about the acceptability and practical implementation of the sessions.

Several limitations should be considered. The study was conducted at a single institution, and 12 of the 100 enrolled students were not included in the paired analysis. There was no separate control group, and students continued to receive conventional teaching during the intervention period. Therefore, improvements could also have been influenced by routine teaching, repeated assessments, or independent study. Long-term knowledge retention was not assessed. Clinical integration, problem-solving, and retention were largely evaluated through perceptions rather than separate objective measures of these skills. Faculty feedback was obtained from only four facilitators, limiting its generalizability.

Implications and Future Directions

Structured CBL may be considered as a supplementary teaching method within undergraduate Physiology, particularly for topics where clinical examples can clarify physiological mechanisms. Its regular implementation would require appropriate time allocation, faculty preparation, and carefully designed cases. Further multicenter studies with comparison groups, validated assessment tools, and longer follow-up periods would help determine its additional educational value, including effects on knowledge retention and objectively assessed clinical reasoning.

CONCLUSION

The implementation of structured Case-Based Learning (CBL) modules in first-year MBBS Physiology was associated with a significant improvement in students' post-test scores across all eight modules. Students also demonstrated a shift towards higher knowledge categories following the intervention. Both students and faculty reported favourable perceptions regarding conceptual understanding, clinical integration, active participation, and the usefulness of CBL in routine teaching.

These findings suggest that structured CBL may be a useful supplementary approach to conventional Physiology teaching under the competency-based medical curriculum. However, the absence of a control group and long-term follow-up limits conclusions regarding its independent effectiveness and knowledge retention. Further controlled studies are needed to assess its sustained educational benefits.

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Conflicts of Interest

The authors declare that there are no conflicts of interest.

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