


# The Effect of the Case-Based Learning Method on the Achievement Motivation of Medical Students

Azizeh Barry<sup>1</sup>, Zohreh Sohrabi<sup>2\*</sup> , Mitra Nourbakhsh<sup>3</sup>, Akram Zhianifard<sup>1</sup>, Azam Norouzi<sup>4</sup>, Monire Barry<sup>5</sup>, Elham Ramezani<sup>1</sup>, Zahra Nouri Khaneghah<sup>1</sup>, Zahra Mirzaee<sup>1</sup>

Received: 3 Jan 2025

Published: 20 Oct 2025

## Abstract

**Background:** Medical education requires continuous improvements in teaching methods to ensure higher-quality learning outcomes for students. Case-Based Learning (CBL) has gained attention as an innovative method to enhance student engagement and achievement motivation. This study aimed to evaluate the effect of CBL on the achievement motivation of medical students.

**Methods:** This quasi-experimental study employed a two-group pre-test-post-test design. The study sample consisted of 70 medical students (36 in the control group and 34 in the intervention group), selected using simple random sampling. The Herman's Academic Achievement Motivation Questionnaire (Cronbach's alpha = 0.84) was used to measure achievement motivation. Data were analyzed using SPSS software. The intervention group participated in a CBL-based teaching approach.

**Results:** Results revealed a significant difference in achievement motivation scores between the pre-test and post-test in the intervention group ( $P = 0.001$ ), indicating the positive effect of CBL on students' motivation. However, no significant difference was observed in the control group ( $P = 0.726$ ). The results of the independent t-test showed that the achievement motivation scores between the intervention and control groups were not significantly different ( $P = 0.556$ ).

**Conclusion:** CBL significantly enhanced achievement motivation in medical students. Integrating CBL into basic science courses, such as biochemistry, is recommended to foster higher motivation and academic success.

**Keywords:** Case-based teaching, Basic sciences, achievement motivation, Medical students

**Conflicts of Interest:** None declared

**Funding:** Iran University of Medical Sciences

\*This work has been published under CC BY-NC-SA 4.0 license.

Copyright© Iran University of Medical Sciences

**Cite this article as:** Barry A, Sohrabi Z, Nourbakhsh M, Zhianifard A, Norouzi A, Barry M, Ramezani E, Nouri Khaneghah Z, Mirzaee Z. The Effect of the Case-Based Learning Method on the Achievement Motivation of Medical Students. *Med J Islam Repub Iran*. 2025 (20 Oct);39:134. <https://doi.org/10.47176/mjiri.39.134>

## Introduction

Motivation is a key factor in medical education, influencing students' engagement, academic success, and long-term learning outcomes. Despite its importance, many medical students lack sufficient motivation when facing challenging basic science courses, such as biochemistry. This study investigates the impact of the Case-Based

Learning (CBL) method on enhancing medical students' achievement motivation (1).

In the educational system of medical sciences universities, teaching quality is of particular importance due to the specialized nature of the courses offered. Improving educational quality requires innovation in teaching methods.

**Corresponding author:** Dr Zohreh Sohrabi, [Sohrbiz@iums.ac.ir](mailto:Sohrbiz@iums.ac.ir)

<sup>1</sup> Center for Educational Research in Medical Sciences (CERMS), Department of Medical Education, School of Medicine, Iran University of Medical Sciences, Tehran, Iran

<sup>2</sup> Department of Medical Education, Faculty of Medicine, Vice-Director, Center for Educational Research in Medical Sciences (CERMS), Iran University of Medical Sciences, Tehran, Iran

<sup>3</sup> Department of Biochemistry, School of Medicine, Iran University of Medical Sciences, Tehran, Iran

<sup>4</sup> Department of Medical Education, School of Medicine, Mashhad University of Medical Sciences, Mashhad, Iran

<sup>5</sup> Department of Nursing, Islamic Azad University of Uremia, Uremia, Iran

### ↑What is “already known” in this topic:

Traditional lecture-based methods are widely used in medical education but often fail to maintain long-term student motivation and engagement, especially in challenging courses like biochemistry. Case-Based Learning (CBL) has been previously recognized for its potential to enhance learning by fostering critical thinking, problem-solving, and clinical relevance. Prior studies suggest that active learning approaches may positively influence student motivation.

### →What this article adds:

This study provides empirical evidence from a quasi-experimental design showing that the CBL method significantly improves achievement motivation among medical students in basic science courses. It highlights the impact of CBL in biochemistry education, bridging the gap between theoretical knowledge and clinical application, and suggests its broader implementation to enhance academic outcomes.

Despite the continued dominance of lecture-based instruction, studies show that nearly 80% of lecture content is forgotten within 8 weeks. This inefficiency has led educators to seek more effective, student-centered approaches to teaching (2).

Over recent decades, there has been a growing need to shift from traditional to active learning strategies. Active learning engages students in cooperative, high-level cognitive tasks, fostering critical thinking and deeper understanding (3). An essential goal of education is to nurture individuals with the motivation and capacity to solve complex problems and expand their scientific knowledge (4).

Teaching basic sciences using innovative methods—especially those connecting theoretical content to clinical contexts—can increase students' interest and motivation to learn (3). Case-Based Learning (CBL) is one such approach that promotes problem-solving and performance competence in a fast-changing, globalized world. From a structuralist perspective, active learning encourages meaningful learning through problem-oriented tasks. Moreover, CBL aligns with behaviorist, cognitivist, and structuralist theories, supporting skill acquisition across diverse learning domains (5, 6).

Biochemistry, a key course in medical curricula, aims to familiarize students with metabolic diseases and diagnostic testing related to the liver, kidneys, cardiovascular system, endocrine disorders, and acid-base imbalances. Despite its relevance, many medical students perceive biochemistry as one of the most difficult subjects and struggle with it, which negatively impacts their learning experience and academic outcomes (7). CBL has shown promise in bridging the gap between theory and practice, enhancing students' analytical, clinical, and communication skills. It serves as an effective strategy for increasing engagement, critical thinking, and motivation (8, 9). Numerous studies have confirmed CBL's positive effects on learning outcomes, student interaction, participation, and satisfaction across medical courses, including pharmacology (9–15).

Given the importance of biochemistry, the challenges students face, and the low levels of engagement reported, innovative teaching strategies like CBL, Inquiry-Based Learning, and Problem-Based Learning can significantly enhance deep learning, motivation, and academic performance (7, 11). Therefore, the present study aims to examine the impact of Case-Based Learning on medical students' achievement motivation.

## Methods

### Design and setting(s)

This quasi-experimental study utilized a pre-test-post-test control group design to assess the effect of Case-Based Learning (CBL) on the achievement motivation of medical students. The research was conducted in 2022–2023 at Iran University of Medical Sciences. This study was designed as a quasi-experimental study. Randomization was not used to assign participants to the groups. Instead, a random allocation method was applied to assign participants to either the intervention or control group, which does not meet the criteria for a fully randomized controlled trial (RCT).

### Participants and sampling

The study population consisted of all medical students enrolled in a basic sciences course during the academic year 2022.

Recruitment was conducted based on predetermined inclusion and exclusion standards,

not randomly from the entire student population. Inclusion criteria included: (1) enrollment in the basic science course, (2) willingness to participate, and (3) providing informed consent. Exclusion criteria were: (1) unwillingness to participate, (2) being an intern or in clinical stage, and (3) incomplete questionnaire responses.

### Sample Size

The required sample size was calculated using G\*Power software, with a confidence level of 95%, a test power of 90%, and based on data from a previous similar study by Heidari et al. (27). Considering a 20% potential dropout, 36 students were assigned to each group (total = 72). Eventually, 34 students remained in the intervention group and 36 in the control group. In this study, a statistical power of 90% was used to detect significant differences between groups. This value is commonly chosen in medical research to ensure that the probability of detecting a true difference, as opposed to a random fluctuation, is sufficiently high. A 20% dropout rate was accounted for in the sample size calculation. This percentage is commonly used to adjust for participant attrition or incomplete data during the course of the study.

### Group Allocation and Intervention

Participants were divided into two classes by the university. One class was assigned to the intervention group (CBL method), and the other served as the control group (traditional lecture-based method). The allocation was done using block randomization via Excel software, ensuring group equivalence. The intervention (CBL) was conducted over six sessions, each lasting 90 minutes, focusing on clinical biochemistry cases relevant to course objectives (Appendix). In this study, random allocation was used for assigning participants to groups. A random number table was employed to assign one class to the intervention group and another to the control group. This method was chosen to ensure unbiased distribution and avoid selection bias in group allocation.

### Pre-test and Post-test

Before the intervention, both groups completed an achievement motivation questionnaire. The same questionnaire was administered again at the end of the 6-week intervention to assess the impact. The pre-test and post-test were conducted using a standardized achievement motivation questionnaire. The intervention consisted of Case-Based Learning (CBL) implemented over a period of 4 weeks. The CBL approach was designed to engage students in problem-solving tasks related to basic science topics. The primary outcome measured was the change in achievement motivation scores from pre-test to post-test.

### Data Analysis

The collected data were analyzed using SPSS version 23. Descriptive statistics (mean, SD) were used to summarize data. Paired t-tests were used to compare pre- and post-test scores within groups, and independent t-tests were used to compare differences between groups. A  $P$ -value  $< 0.05$  was considered statistically significant.

### Tools/Instruments

The instrument used was the Hermans (1970) academic achievement motivation questionnaire. This questionnaire initially included 92 questions, but based on the existing research, 10 characteristics that differentiated people with high achievement motivation from those with low achievement motivation were taken into consideration to create the questionnaire, and based on the number of achievement coefficients, the number of questions in the questionnaire was reduced to 29 questions. The questions of this questionnaire were presented in the form of 29 incomplete sentences with four options (Self-confidence (1-7), perseverance and choosing a job (8- 13), foresight (14- 19), and hard work (20-29)). The scoring of the questionnaire was conducted according to the nine characteristics on which the questions were prepared. In this scale, high and low scores indicated high and low achievement motivations, respectively. To calculate validity, Hermans used content validity, which was based on previous research on motivation for achievement, and he also calculated the correlation coefficient of each item with achievement-oriented behaviors. The coefficients were in the range of 0.3 to 0.5 according to the questionnaire questions. In 1970, Hermans calculated the reliability of the academic achievement motivation test using Cronbach's alpha test method. This questionnaire was psychometrically evaluated in Iran in Akbari et al.'s study. Cronbach's alpha was 0.84, and it also had acceptable face and content validity (18).

### Data collection methods

At the outset of the study, the researcher introduced himself and provided a concise overview of the research, including its objectives and potential applications. Students who met the eligibility criteria and expressed willingness to participate were then invited to complete the informed consent form.

This study was done in three phases:

First, before the intervention, an initial pre-test was conducted using the academic achievement motivation questionnaire in both intervention and control groups. Then, in the intervention group, the CBL teaching method was used. In this way, the topics were presented in 8 sessions by a professor. The sessions were held in person. During the class, several short scenarios relevant to the course material for students were presented. After allowing time for evaluation, a series of questions was presented using an online voting system. Real-time results were displayed, and based on them, both incorrect and correct answers were discussed with the class.

The control group received the traditional method of teaching (lecture), and 2 weeks after the intervention, a post-test (identical to the pre-test using the Hermans

Academic Achievement Motivation Questionnaire) was administered to both the intervention group and the control group. Following data collection, analysis was conducted using descriptive and analytical statistics.

The purpose of case-based learning is to prepare students for clinical practice using real clinical cases. In the case-based method, a specific case is presented about a real situation in the form of a scenario, which requires the solution of the problem and making a decision. The professor proposes the scenario, and the students are required to listen attentively and take notes. Afterward, the students are allowed to reflect on the topic. Then the professor starts his questions with an open question, and asks the students to take part in the discussions, and if needed, the professor gives further information, such as symptoms and diagnostic tests. In this method, the teacher plays the role of the initiator, mediator, and facilitator of the learning process and guides the students toward the goals of the class (13).

### Results

The data were analyzed using both descriptive and inferential statistics. The Kolmogorov-Smirnov test was used to assess the normality of the data, and parametric tests, including t-tests and analysis of variance (ANOVA), were applied to evaluate the research questions. The research sample consisted of 36 students in the control group (0.51) and 34 students in the intervention group (0.49).

The data presented in the table indicate that, in both groups, the majority of participants were around 20 years old. Results from the independent t-test revealed no statistically significant difference in mean age between the two groups ( $P = 0.059$ ). Regarding gender distribution, 50% of participants in the intervention group were male and 50% were female, while the control group consisted of 53% males and 47% females. In terms of marital status, there were 33 single participants in the control group and 32 in the intervention group. The chi-square test results showed no statistically significant difference between the groups in gender composition ( $P = 0.738$ ) (Table 1).

The data in the above table shows the average variable of the average of the sample in two groups, which shows that the Academic average of the majority of the samples of both groups is in the range of 16.90, and there was no statistically significant difference between the two groups. According to the Kolmogorov-Smirnov test, the significance levels obtained for the main variable of the research, which is greater than 0.05, indicate that the data of the variable is normal, and parametric tests should be used to test it (Table 2).

At the baseline (pre-test), there were no statistically significant differences between the two groups. The results of the independent t-test showed that the achievement motivation scores between the intervention and control groups were not significantly different ( $P = 0.556$ ) (Table 3).

While there was a statistically significant difference in achievement motivation scores at the pre-test stage ( $P = 0.0001$ ), this difference was not between the groups, but rather within each group, suggesting that both groups initially had some variation in their baseline levels of motivation. This finding justifies the need for further investigation of

Table 1. Distribution of participants in terms of age and gender for both groups

Age	Control Group (Common/speech)		Intervention Group (CBL)	
	Mean±SD		Mean±SD	
Independent T-test Results	20.52 ±4.91		19.41 ± 1.10	
	T=1.930 df=69 P = 0.059			
Gender	Frequency	Percentage	Frequency	Percentage
Male	17	50%	19	53%
Female	17	50%	17	47%
Total	34	100%	36	36%

Chi-Square Test Results  $X^2=0.602$  Df=1 P =0.738

Table 2. Distribution of statistical sample according to Academic average GPA in two groups

	Intervention Group	Control Group
	Mean And Standard Deviation	Mean And Standard Deviation
Academic average	16.87 ±1.75	16.91 ±1.05
Independent T-Test Results	T=1.306 Df=68 P =0.772	

Table 3. Independent t-test to check the difference between the mean achievement motivation in pre- and post-test in students in two groups

Variable	Stage	Mean	The Standard Deviation	P-Value	
Pre-Test	Achievement Motivation	The intervention	68.314	8.54	0.556
		Control	69.702	8.19	
Post-Test	Achievement Motivation	The intervention	89.738	9.82	0.000
		Control	70.210	8.39	

Table 4. The results of the covariance analysis of two intervention and control groups in the level of achievement motivation

Achievement Motivation	Sum of Squares	Degrees of Freedom	Mean Square	F Value	P value	Effect Rate	Statistical Power
Post-Test (Intervention Group)	38.52	1	52.16	20.17	<0.001	0.58	0.05
Post-Test (Control Group)	36.12	58	44.26	8.66	0.001	0.03	-
Group	9.204	1	9.480	28.55	<0.001	-	0.01
Error	13.60	4	60.39	-	-	-	-
Total	119.33	66	-	-	-	-	-

Table 5. One-factor variance analysis of students' achievement motivation assessment according to gender

Statistical Indexes	Number	Mean	The Standard Deviation	Standard Error	T Observed	P value
Gender						
Female	34	74.09	6.58	1.49	3.96	<0.001
Male	36	70.46	5.23	1.87	-	-

the intervention's effect on post-test scores. The study aims to evaluate whether the CBL method can lead to significant improvements in achievement motivation after the intervention, compared to the control group.

Based on the results obtained from Levine's test for checking the homogeneity of variance between the intervention and control groups, the significance level was 0.327. Since this value is greater than the critical value at the 0.95 confidence level (0.05), the assumption of homogeneity of variance is confirmed (Table 4).

Findings of the covariance analysis in Table 4 show a significant difference between the achievement motivation of the intervention and control groups ( $P < 0.001$ ) and F (20.17). Its square is equal to 0.58, that is, 28% of the achievement motivation is related to the implementation of training through CBL. In other words, it can be said that teaching through CBL has a significant effect on the motivation level of students' achievement (Table 4).

As shown in Table 5, after the intervention, there was a significant difference between the two groups in terms of achievement motivation scores ( $P < 0.001$ ). The F-value from the analysis of covariance (ANCOVA) was 20.17, with a partial eta squared of 0.58, indicating that 28% of the variance in achievement motivation can be explained by the CBL method. These findings demonstrate that the CBL intervention had a significant effect on the achievement motivation of the students. Additionally, gender was identified as a significant variable influencing achievement motivation, with a P-value of 0.001 (Table 5).

### Discussion

The objective of this research was to assess how Case-Based Learning (CBL) influences achievement motivation among medical students studying basic sciences at Iran University of Medical Sciences.

The findings indicated a significant and positive effect

of the CBL intervention on students' motivation to excel in their studies.

A key aspect of medical education is the evolution of teaching methods, which is a topic under increasing consideration in universities worldwide. Previous research has shown that various instructional strategies, including active learning approaches like CBL, can significantly influence students' academic motivation. The importance of motivation in medical education cannot be overstated, as motivated students are more likely to engage with course material and perform better academically. This shift from teacher-centered to student-centered learning, with a focus on fostering deeper engagement through innovative teaching methods, is increasingly recognized as essential for improving learning outcomes (1).

The results of this study are in line with the findings of several other studies that have investigated the effectiveness of CBL in medical education. Specifically, the CBL method creates a meaningful connection between theoretical knowledge in basic sciences and its clinical applications. This helps medical students see the relevance of their coursework to their future clinical practices, which in turn enhances their motivation and interest in learning. According to Babaei's study at Gilan University, CBL successfully bridged the gap between theoretical education and its clinical application, fostering higher levels of student motivation and engagement (15). Similarly, Sanaa Eissa's research also demonstrated positive outcomes, including the enhancement of critical thinking, problem-solving, time management, and teamwork skills, which are vital for medical practice. These skills contribute to a better understanding of the relationship between basic sciences like biochemistry and clinical practice (23).

Moreover, CBL has been shown to support collaborative learning, improve knowledge retention, and foster critical thinking. These findings align with the work of Shahnam et al., who identified a positive relationship between academic motivation and self-directed learning. This suggests that incorporating CBL into medical education could help develop essential skills such as independent learning and critical analysis, which are fundamental for future medical practitioners (20).

The findings of this study also echo the work of Nouhi et al., who reported that problem-solving learning methods, such as CBL, encourage active participation and collaboration among students, leading to the development of critical thinking and independent learning (21). This is consistent with the increasing recognition of CBL as a powerful tool for improving student performance and engagement in medical education (22–27). In conclusion, the results of this study support the growing body of evidence suggesting that CBL is an effective teaching method for enhancing students' motivation and academic performance. The integration of CBL into basic science courses, especially biochemistry, can foster deeper learning and motivation, ultimately improving the educational experience and preparing students for future clinical challenges.

#### **Strengths and weaknesses and limitations**

One of the most important limitations of this study is the

follow-up period, which was short. The strength of this study was the emphasis on important variables such as motivation for progress and new teaching methods. Given the quasi-experimental design of the study, certain limitations were present, including a small sample size and limited generalizability of the results. Therefore, extending the findings to other fields within the medical sciences should be approached with caution. It is recommended that future studies employ larger sample sizes and implement this intervention across other groups as well.

#### **Conclusion**

The main core of education is to create a suitable environment for students to interact and learn to grow and progress. In recent decades, educational systems have felt the need to improve teaching methods and employ new methods and active learning, and the use of these methods has become common in various fields of medical education. Since one of the effective factors on the student's achievement motivation is the effectiveness of teaching and learning in universities and higher education centers, in this field, the efficiency of educational methods is one of the important criteria of any educational system. Therefore, it is suggested that basic science courses, especially biochemistry, should be taught on a case-based basis (CBL) to increase the motivation of students to achieve.

#### **Authors' Contributions**

Conceptualization: A.B and Z.S  
 Data curation: M.N, A.ZH, A.N and M.B  
 Formal analysis: E.R, Z.N.KH and Z.M  
 Funding acquisition: A.B and Z.S  
 Methodology: A.B, Z.S M.N, A.ZH and A.N  
 Project administration: A.B and Z.S  
 Writing original draft – review & editing: All authors..

#### **Ethical Considerations**

The Iran University of Medical Sciences ethics committee approved the study (code IR.IUMS.FMD.REC.1402.380).

#### **Acknowledgment**

The authors of this research consider it necessary to thank and appreciate the hard work and sincere cooperation of all the participants during the study.

#### **Conflict of Interests**

The authors declare that they have no competing interests.

#### **References**

- Haghani F, Bakhtiari S, Ghaedi Heidari F. Effect of game based teaching on satisfaction and learning of midwifery students in social psychology course. *Education and Ethics In Nursing*. 2018;7(1-2):375-82.
- Rahimimand M, Abbaspour A. The Relationship between teaching methods (group discussion, questions and answers, scientific demonstration and lectures) with Student achievement motivation. *Educational Psychology*. 2016;12(39):1-24.
- Mehralizadeh S, Pourhoseini M, Ghorbani R, Zolfaghary S. Factors affecting learning of anatomy: students' viewpoints.

- Iranian Journal of Medical Education. 2013;13(1):49-57.
4. Pangaro L. The role and value of the basic sciences in medical education: the perspective of clinical education-students' progress from understanding to action. *J Int Assoc Med Sci Educ.* 2010;20(3):307-313.
  5. Paknia B, Rafiei M, Khorsandi M, Ramezani G. Effects of the Blended Workshop Learning and Web-Based Learning Sequence on the Learning Level: A New Experiment. *Journal of Iranian Medical Council.* 2024;7(1):70-79.
  6. Ramezani G, Norouzi A, Arabshahi SKS, Sohrabi Z, Zazoli AZ, Saravani S, Pourbairamian G. Study of medical students' learning approaches and their association with academic performance and problem-solving styles. *J Educ Health Promot.* 2022 Aug 25;11:252.
  7. Panjehpour M, Ataei N. Comparison of cooperating active and traditional teaching methods in medicine student satisfaction and learning of Clinical Biochemistry in pharmacy students. *Journal of Medical Education Development.* 2015;8(19):81-91.
  8. Yeganeh A, Moghtadaei M, Hoveidamanesh S, Ramezani G, Hashemi A. Comparison of Students' Attitudes about the Effectiveness of Algorithm-based Education with Lecture-based Education. *Med J Islam Repub Iran.* 2022;36(1):1309-1314.
  9. Dominguez I, Zumwalt AC. Integrating the basic sciences in medical curricula: focus on the basic scientists. *American Physiological Society Bethesda, MD;* 2020. p. 119-23.
  10. Hosseini zarrabi H, Khorasani A, Rezaeizadeh M, Mazaheri Tehrani MA. Investigating the methods of creating interaction and improving students' engagement in the learning process in higher education: A systematic review. *New Educational Approaches.* 2021;16(1):77-96.
  11. Arab F, Saeedi M. The effect of the case-based learning approach on the level of satisfactions and learning of nursing students in Iran: A randomized controlled trial. *Heliyon.* 2024 Jul 24;10(15):e35149.
  12. Babaei P. Comparing Traditional Lecture and Combination of Case And Lecture in Teaching Endocrine Physiology for Medical Students. *Research in Medical Education.* 2022;4(1):1-8.
  13. Awidi IT, Paynter M, Vujosevic T. Facebook group in the learning design of a higher education course: An analysis of factors influencing positive learning experience for students. *Computers and Education.* 2019;129:106–121.
  14. Cesari V, Galgani B, Gemignani A, Menicucci D. Enhancing qualities of consciousness during online learning via multisensory interactions. *Behavioral Sciences.* 2021;11(5):57.
  15. Sjöholm J, Trygg K. CBL and living labs: towards a methodology for teaching sustainability transitions in urban planning education. *Journal of Geography in Higher Education.* 2024:1–17.
  16. Luo M, Zhang X, Liu W. Effect Evaluation of CBL Combined with Rain Classroom Teaching Method in Medical Statistics. *Open Journal of Applied Sciences.* 2024;14:204-1213.
  17. Khazaei MR, Moradi E, Barry A, Keshavarzi MH, Hashemi A, Ramezani G, et al. Effect of flipped classroom method on the reflection ability in nursing students in the professional ethics course; Solomon four-group design. *BMC Med Educ.* 2025 Jan 13;25(1):56.
  18. Heidari F, Mottaghi R. The effectiveness of life skills training on cognitive flexibility and quality of life in elderly people with diabetes mellitus type-2: A quasi-experimental study. *The Journal of Rafsanjan University of Medical Sciences.* 2023;22(4):367-384.
  19. Akbari B. Validity and validity of Hermance achievement motivation test on high school students of Gilan province. *Research in curriculum planning (knowledge and research in educational sciences-curriculum planning).* 2009;21(16):73-96.
  20. Fani M, Davoodian N, Moghimian M, Khajavian N. Comparison of Traditional and Integrated Methods of Teaching Endocrinology and Reproductive Physiology at Gonabad University of Medical Sciences: Attitude and Learning. *Navid No.* 2021;23(76):44-51.
  21. Maroufi SS, Moradimajd P, Jalali M, Ramezani G, Alizadeh S. Investigating the current status of the student evaluation system in Iran University of Medical Sciences: A step to improve education. *J Educ Health Promot.* 2021 Jun 30;10:231. doi: 10.4103/jehp.jehp\_1428\_20. PMID: 34395668; PMCID: PMC8318155.
  22. Eissa S, Sallam RM, Moustafa AS, Hammouda AM. Large-scale application of case-based learning for teaching medical biochemistry: a challenging experience with positive impacts. *Innovation and Education.* 2020;2(1):1-19.
  23. Malau-Aduli BS, Lee AY, Cooling N, Catchpole M, Jose M, Turner R. Retention of knowledge and perceived relevance of basic sciences in an integrated case-based learning (CBL) curriculum. *BMC medical education.* 2013;13:1-8.
  24. Srinivasan M, Wilkes M, Stevenson F, Nguyen T, Slavin S. Comparing problem-based learning with case-based learning: effects of a major curricular shift at two institutions. *Academic Medicine.* 2007;82(1):74-82.
  25. Thistlethwaite JE, Davies D, Ekeocha S, Kidd JM, MacDougall C, Matthews P, et al. The effectiveness of case-based learning in health professional education. A BEME systematic review: BEME Guide No. 23. *Medical teacher.* 2012;34(6):421-44.
  26. Rasouli D, Norouzi A, Ramezani G, Hashemi A. A psychometric evaluation of inter-professional education competency tool in nursing and medicine students. *BMC Med Educ.* 2024;24:110.
  27. Nojomi M, Goharinezhad S, Saraei R, Goharinejad S, Ramezani G, Aalaa M. Exploring the attitudes of general medical students toward older adult's care in a lower middle-income country: implications for medical education. *BMC Med Educ.* 2023 Sep 8;23(1):649. doi: 10.1186/s12909-023-04626-1. PMID: 37684593; PMCID: PMC10492309.

*Appendix.* The intervention (CBL) was conducted over 8 sessions, fo-cusing on clinical biochemistry cases relevant to course objectives

Ses- sion	Topic	Scenario	Questions
1	Bioenergetics	Sara is an athlete. She trains for a 200-meter sprint race. However, she performs endurance 5000-meter runs once a week, and strength training 3 days a week. Once she increases the load of exercise, she feels soreness in her muscles.	<p>What is the fuel of muscle cells?            How long can the ATP that is already inside the cells provide the energy?            Is ATP stored in the cell?            If not, then how can a muscle cell manage to provide energy for continuous work?            Compare the metabolism in the sprint race with the endurance run? Aerobic or anaerobic?            What do you think is the reason for sore muscles, and why?</p>
2	Electron transport chain	A young woman presents to the emergency department due to a suicide attempt by ingestion of about 50 grams of bitter almonds with complaints of nausea and vomiting. Venous blood gas analysis reveals severe metabolic acidosis. The patient became comatose soon after admission but regained consciousness several hours after treatment.	<p>What is in bitter almond that has caused the patient's symptoms?            Considering Cyanide inhibits complex IV of the respiratory chain, why has it caused the intoxication symptoms?            Why is the patient comatose?            What is the reason for acidosis?</p>
3	Beta-oxidation defect	A seven-year-old boy presents to the emergency department with nausea, vomiting, lethargy, and weakness. His mother says that he had mild physical activity and refused to eat his dinner last night, went to bed, and the next morning woke up with the above symptoms. Lab evaluation showed lowered blood glucose and low ketone bodies in urine.	<p>What is the main fuel for the body at the time of prolonged fasting or intense physical activity?            What do you think is the reason for mental symptoms?            Why has hypoglycemia occurred in this patient, although the glucose metabolism is normal?            What is the expected level of ketones in the state of hypoglycemia?            Why are ketone levels low in this patient?            What is your suggested treatment for this patient?</p>
4	Carnitine shuttle defect	Two patients are presented here: both have symptoms of the defect in fatty acid oxidation. Apart from hypoketotic hypoglycemia, the first one shows high levels of carnitine, while the carnitine levels are low. The latter was treated with L-carnitine. Both responded well to medium-chain triglyceride (MCT) oil.	<p>How is carnitine connected to fatty acid oxidation?            Why only one patient benefited from carnitine supplementation?            Which part of the carnitine shuttle can lead to high levels of carnitine? Which to low levels?            Why has MCT oil been effective in treating the patients?</p>
5	Lipid biosynthesis	A patient with type 2 diabetes has undergone liver function tests, and high levels of liver enzymes have been found together with high bilirubin. Further evaluation through ultrasound indicated grade 3 liver steatosis. The physician recommended controlling blood glucose. The patient asks about Firsocostat a drug he has heard about, which is in phase II clinical trial.	<p>How are high blood glucose levels and high blood insulin connected to lipid accumulation in the liver?            What is the effect of insulin on lipids in adipose tissue? What is expected from thhormone-sensitive lipase in case of insulin resistance? What is expected for the free fatty acid levels and their fate?            Firsocostat is an inhibitor of acetyl-CoA carboxylase. How can it prevent lipid accumulation? What is the role of this enzyme in lipid metabolism?</p>
6	Cholesterol biosynthesis	A 62-year-old woman has been referred due to hypertension. In the initial evaluation, hypercholesterolemia is found. She states that her mother had coronary artery disease. She does not smoke or drink alcohol, and her blood glucose level is normal. She was recommended to follow a strict low-fat, low-carbohydrate diet containing lots of fruits and vegetables, and do regular physical activity. She returns 3 months later, and no improvement is noticed. Therefore, atorvastatin is prescribed for her. In the next visit, a significant reduction in cholesterol is noticed.	<p>Why should the doctor be concerned about the blood glucose levels of the patient?            How can vegetables help lower blood cholesterol levels?            If statins target the metabolism of cholesterol, which enzyme is more suitable for inhibition?            What other pathways can be considered for lowering blood cholesterol if the patient did not respond to statins?            Ezetimibe is a drug that inhibits cholesterol absorption. What is its target?            How does inhibition of bile reabsorption help reduce blood cholesterol levels?</p>
7	Cofactors and trace elements	A 34-year-old woman presents to her physician with complaints of increasing fatigue, dizziness, and shortness of breath over the past few months. She had two pregnancies and regularly has heavy menstruation. Lab evaluations include red blood cell count, hemoglobin levels, serum iron levels, total iron binding capacity (TIBC), and ferritin levels. The physician's diagnosis is iron-deficiency anemia.	<p>Why has iron deficiency caused these symptoms?            How can heavy bleeding lead to iron deficiency?            Why is red blood cell count and hemoglobin useful for the evaluation of iron deficiency?            TIBC is related to which of the serum proteins?            What do you expect for the TIBC and ferritin levels in this patient and why?</p>
8	Cofactors and trace elements	A 45-year-old man presents to the clinic with progressive weakness and numbness in his legs and difficulty walking. Recently, he has noticed unexplained fatigue and difficulty concentrating. He also complains about easy bruising. He reports a history of bariatric surgery due to morbid obesity and, since then, takes daily iron and zinc supplements. The physician orders measurement of serum copper and ceruloplasmin.	<p>What is the relationship between copper and the weakness and fatigue in this patient? What is the relationship with poor concentration?            How can copper be related to the weakness of blood vessels?            How can taking continuous high doses of iron and zinc contribute to copper deficiency?            Why has the physician ordered ceruloplasmin measurement along with copper levels?</p>