

ARTICLE

Online case-based learning for medical students as a teaching method for biochemistry at King Abdulaziz University amid COVID-19 pandemic (a study conducted in 2021)

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Abstract

Online case-based learning (CBL) is a method used by King Abdulaziz University to teach medical students in their preclinical years. The use of CBL in basic sciences is important for enabling medical students to correlate basic sciences with future clinical practice. This study implemented online CBL for biochemistry teaching as part of the medical genetic module for 3rd-year preclinical students. Teaching during the study was completely online because of restricted precautions caused by the COVID-19 pandemic, except for practical sessions that were held on campus. The case was presented to the students involved in prenatal screening and diagnosis. Students were guided to learn and discuss the biochemical tests used for prenatal screening and diagnosis and their clinical importance. They were divided into two groups: the control group was given an online lecture and the intervention group was given an online CBL session before the lecture. The online lecture was given to both groups simultaneously by the same instructor, and then 10 MCQs tests were distributed to both groups after the lecture, and their test scores were compared. A 10-question survey was administered to the intervention group to assess their perception of the online CBL session after the test. A significant difference was found between the intervention and control groups regarding test scores ($p < 0.001$), and most students found the online CBL session enjoyable and motivating.

KEYWORDS

biochemistry, COVID-19, genetic module, medical students, online CBL, preclinical years

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1 | INTRODUCTION

The international health crisis caused by COVID-19 has led to over 3.2 million deaths and more than 156 million confirmed cases, overwhelming the healthcare system, and causing changes in daily activities and social interactions among the population.¹ Meanwhile, the pandemic has thrown its shadow on more than 1.53 billion students in over 184 countries worldwide.² The Impact of which has transcended health to education, leading to educational changes and increased implementation of online learning.³ Online learning has become increasingly important in educational systems since curfews and closures began in early 2020.⁴

The shift from face-to-face to online learning during the pandemic forced students to switch to new learning methods, increasing their anxiety.⁵ In addition, the highly contagious nature of the novel coronavirus led to difficulties in delivering conventional lectures and clinical hospital-based education.⁶ This has led to the deterioration of training in medical education, as was shown by a survey conducted by Sahana Giliyaru et al., where three-quarter of surveyed medical students felt that their training has deteriorated and 60% revealed that the pandemic had changed their choice of future specialty.⁷

Another adverse effect of COVID-19 on medical education is its negative effects on clinical skills, clinical experience, and residency training.⁸ Moreover, distance learning faces many challenges, such as unstable electrical power, Internet inefficiency, digital skills, and the availability of online platforms and tools.⁹ Another critical challenge is student satisfaction, which has become an essential tool for evaluating the performance of universities and is considered one of the goals of higher education.¹⁰

Online learning also has several advantages including time, pace, and place flexibility, in addition to the development of critical thinking.¹¹ Owing to mobile devices that can connect to the Internet, students can continue learning using easily accessible digital tools.¹²

Online learning is increasingly used in education because of the low number of health workers; furthermore, it improves students' interactions and understanding. It can take the form of fully online teaching or mixed education between conventional and computer-based learning (blended learning) and is more suitable for medical students. Recently, medical schools in Canada and the USA have employed blended or full online teaching. Many student activities and teaching methods including discussions, student interactions, cognitive enhancement, and presentations can be conducted online.¹³ Consequently, traditional learning methods should be

reconsidered, specifically in today's internet facilities and digital information revolution. Unlike conventional learning, e-learning is not restricted by space and time, and it has increased since 2012.¹⁴

One of the essential methods used in medical education is case-based learning (CBL), in which students are divided into small groups and given real clinical scenarios to assess their analytical skills and are encouraged to engage in discussion with their peers guided by a content expert facilitator.¹⁵

It is essential to present real cases to medical students during their study years representing different biomedical problems to help them understand the fundamentals of medicine and create well-educated future practitioners. CBL depends on a skilled instructor who guides medical students through a medical case and motivates them to ask questions and use critical thinking and reasoning to identify and resolve the problem posed by the selected case.¹⁶ However, it is different from problem-based learning (PBL). In various aspects, medical students in CBL sessions are guided through discussion more than that in PBL.¹⁷ Interactive CBL is an interactive method that enhances collaborative reasoning skills for students in medical fields in e-learning, which consists of the administration of the system, creation of clinical scenarios, and formulation of a case using combined practice knowledge from students and teachers.¹⁸

Moreover, integrating clinical and basic sciences makes teaching more motivating and enjoyable for students. Students are given a clinical scenario in basic sciences that motivates them to gain knowledge through guided learning. Cases should be carefully selected to enhance students' understanding of the materials.¹⁹

2 | MATERIALS AND METHODS

2.1 | Study design

This is a cross-sectional case-control experimental study.

2.2 | Study area

Saudi Arabia, King Abdelaziz University-Rabigh branch, Faculty of Medicine. Faculty of Medicine-Rabigh branch was founded in 2008 in Rabigh city, which is located one and half an hour from Jeddah and in the Western region of Saudi Arabia near the Red Sea. The Faculty of Medicine in Rabigh branch accepts nearly 30–40 female students and 30–50 male students per batch yearly (a total of 60–80 students per batch).

2.3 | Study population

All Male and female medical students in the preclinical years (3rd year) studying in the King Abdelaziz University-Rabigh branch and who aren't on sick leave or holding their courses on time of Data collection can be involved in this study.

2.3.1 | Inclusion criteria

All 3rd-year male or female medical students who are registered at King Abdelaziz University-Rabigh branch, Faculty of medicine, can be included in the study.

2.3.2 | Exclusion criteria

Medical students who are not currently registered at king Abdelaziz university faculty of the medicine-Rabigh branch, on sick leave, or holding their courses on time of data collection will be excluded from the study.

2.4 | Sample size and sampling technique

The sample size will be calculated as follows:

$$n = Z^2 * p (1 - p) / m^2. \text{ where: } n = 1.96^2 * 0.5(1-0.5) / 0.05^2 = 384.1.$$

The no. of students in each batch is nearly 60 students/year,

$$\text{Adjusted sample size} = S / 1 + \{(S - 1) / \text{population}\}.$$

$$n = 384.16 / 1 + [(384.16 - 1) / 60] = 52.$$

So, the sample size is 52 students.

But the sample size was increased to 66 students.

2.4.1 | Pilot study

The questionnaire was distributed first to 10% of the students in the interventional group to assess the accessibility and applicability of the survey and to reveal any language and design difficulties.

2.5 | Methods of data collection (outlines of data collection instruments)

The study was conducted in the Biochemistry department faculty of medicine King Abdulaziz University-Rabigh branch in the academic year 2021–2022, on 17th Feb 2021, all lectures and tutorials were delivered online due

to the Covid-19 pandemic except for practical sessions, which were held on campus under strict health precautions measures. The intended biochemistry lecture was included in the medical genetic module as part of the 3rd-year medical undergraduate students' preclinical curriculum.

Sixty-six students were involved in this study, and they were divided into two groups:

- A. The control group: was composed of 33 students (14 females and 19 males) who were given a two-hour online lecture (the lecture was on the Blackboard platform, which is the main official platform used by the university). The students were not given any learning materials before the session;
- B. The Interventional Group: Was composed of 33 students (13 females and 20 males) who were given a clearly defined clinical case with the objectives related to the intended topic of the lecture, which was distributed electronically to the interventional group before the (CBL online session) via e-mails in addition to WhatsApp groups which were created specifically for this purpose, the students were encouraged to read the materials and study according to the given objectives.

After that, an online CBL session was appointed on Blackboard in which students were encouraged to discuss the clinical case and answer the relevant questions. The facilitator helped them analyze and use problem-solving skills. Students were given a chance to discuss the case in detail and pinpoint the critical keywords and information related to the case. They were allowed to discuss the case with the instructor and were given enough time to resolve the problem, examine their critical thinking, communicate with each other, and discuss the case. The instructor also guided the students and stimulated their problem-solving skills by giving them facts and encouraging them to find a solution to the problem. The facilitator often encouraged students to ask and answer questions and discuss the main objectives. The students were also encouraged to search for the answers to the questions which raised during the discussion.

The online lecture was given to both groups at the same time by the same instructor, for the control group it was the first time for them to learn the topic while for the interventional group the topic was already discussed before the lecture in a separate online CBL session.

After finishing the online lecture, a 10- MCQ test was distributed to both groups.

After completing the test, a survey questionnaire was distributed electronically only to the interventional group to determine how they perceived the online CBL session. The questionnaire was filled out by 30 students.

2.5.1 | Ethical consideration

Ethical approval was approved by the Unit of Biomedical Ethics Research Committee at King Abdulaziz University (Reference No 43-21, No of registration (HA-02-J-008).

Participation in the survey was voluntary, and an informed consent form was included in the introductory section of the online survey. All collected data was treated with confidentiality. All data was anonymized once it had been collected.

2.5.2 | The data analysis plan

Descriptive statistics were used to measure the difference in mean and standard deviations between gender and groups. ANOVA (Analysis of Variance) was conducted to examine the effect of gender and groups on exam scores. The statistical significance was defined as a p -value of <0.05 . The statistical analysis was done using SPSS version 28. The figures were created by Tableau 2021.4.

3 | RESULTS

Sixty-six students were involved in the study (27 females and 39 males) they were separated into two groups:

TABLE 1 Descriptive statistics of score by gender and groups.

Variable	Category	N	Mean	Std. dev.
Gender	Female	27	7.333	2.418
	Male	39	6.179	2.873
Group	Interventional	33	7.788	1.933
	Control	33	5.515	2.97

TABLE 2 ANOVA results.

Factors	Test statistics				Effect size	
	df _M	df _E	F	p	η_p^2	ω_p^2
Gender	1	62	4.066	0.048	0.06	0.04
Group	1	62	12.249	<0.001	0.16	0.15
Gender * Group	1	62	3.447	0.068	0.05	0.04

TABLE 3 Games–Howell results (post-hoc analysis).

Group					95% confidence interval	
Group 1	Group 2	Mean diff.	Std. error	p	Lower CI	Upper CI
Female	Male	1.154	0.463	0.083	−0.15	2.46
Attended	Not attended	2.273	0.436	<0.001	1.04	3.51

interventional (33 students) and control (33 students) groups Table 1.

A 2×2 factorial ANOVA (Analysis of Variance) was conducted to examine the effect of Gender and Groups: (interventional and control groups) on Exam Score.

Significant main effects were found for Gender, $F(1, 62) = 4.07$, $p = 0.048$, $\omega_2p = 0.044$ on exam score.

Regarding the interventional and control Groups, there was a significant difference between the two groups regarding the test score, $F(1, 62) = 12.25$, $p < 0.001$, $\omega_2p = 0.146$.

There was no significant interaction between Gender and Groups, $F(1, 62) = 3.45$, $p = 0.068$, $\omega_2p = 0.036$ (Tables 2 and 3, Figure 1).

Table 4 and Figure 2 show the students' perception about the online CBL session. Thirty students from the interventional group have completed the survey which was conducted shortly after the online session and the Test, the distribution of different Likert scale points between different survey items shows that 90% of students either agree or strongly agree that the Online CBL session has helped them to construct and answer vital questions regarding the clinical case, while 86.7% accepted (agree and strongly agree) that online CBL session enabled them to assess and interpret relevant information, 70% agreed (agree and strongly agree) that the online session helped them to increase their problem-solving ability, 83.3% found the session was motivating, 90% found that it was useful, 96.7% found that the Role of the instructor was very important, 60% found that the session helped them to communicate effectively with their classmates, 73% found the session was interesting, 93.4% of participants found that the session helped them to understand the topic, 73.3% stated that online CBL session is better than traditional learning methods.

Figure 3 shows the steps that were taken by the instructor before, during and after the online CBL session, firstly a clinical case and its objectives was distributed to students in the interventional group via e-mail and WhatsApp, then an online CBL session was given to the interventional group and students were encouraged to discuss the case.

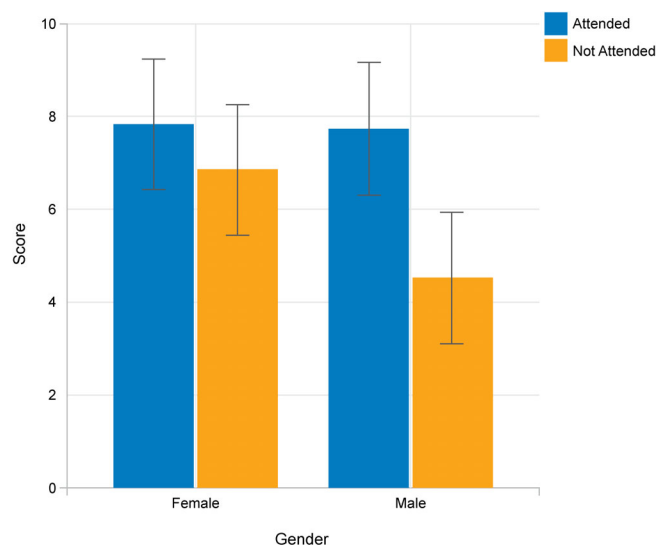


FIGURE 1 Bar diagram showing the relation between test scores and gender in both attended (interventional group which attended the online session) and not-attended groups (control group).

TABLE 4 Students' perceptions of online CBL session.

Survey questions	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
	N (%)	N (%)	N (%)	N (%)	N (line)
Online CBL session helped me to construct and answer vital questions regarding the clinical case	18 (60%)	9 (30%)	3 (10%)	0	0
I feel that online CBL sessions helped me to assess and interpret relevant information	21 (70%)	5 (16.7%)	2 (6.7%)	2 (6.7%)	0
I think online CBL. the session will help me to increase my problem-solving ability in the future	9 (30%)	12 (40%)	7 (23.3%)	2 (6.7%)	0
I find that online CBL session was motivating	21 (70%)	4 (13.3%)	2 (6.7%)	3 (19%)	0
I find online CBL was useful	22 (73.3%)	5 (16.7%)	3 (10%)	0	0
The Role of the instructor was very important in the online CBL session.	27 (90%)	2 (6.7%)	1 (3.3%)	0	0
Online CBL sessions helped me to communicate effectively with my classmates	13 (43.3%)	5 (16.7%)	5 (16.7%)	6 (20%)	1 (3.3%)
I feel the online CBL session was interesting	19 (63.3%)	3 (10%)	5 (16.7%)	3 (10.0%)	0
Online CBL sessions helped me to understand the topic more clearly	23 (76.7%)	5 (16.7%)	2 (6.7%)	0	0
I prefer online CBL sessions to traditional learning methods	19 (63.3%)	3 (10%)	2 (6.7%)	4 (13.3%)	2 (6.7%)

After that both interventional and control groups were given an online conventional lecture on the same topic related to the clinical case and a 10 MCQs test was distributed to both groups.

Finally, a survey was conducted among the interventional group regarding their perception of the online CBL session.

Table 5 shows the grades of the students in both interventional and control groups regarding the test that was conducted shortly after the online conventional lecture.

4 | DISCUSSION

Amid the COVID-19 pandemic, introducing online learning instead of conventional methods was crucial to continue the education process and commit to health precautions. However, implementing online lectures and CBL was challenging, and evaluating the benefits and disadvantages of these methods in medical education was crucial.

This study aims to evaluate and assess the usefulness of online CBL as a teaching method for biochemistry in the preclinical years compared to conventional methods at the College of Medicine.

Our findings suggest that online CBL has a better effect on students' performance when compared to conventional educational methods, and students prefer CBL as an educational method compared to other methods.

Sheet 5

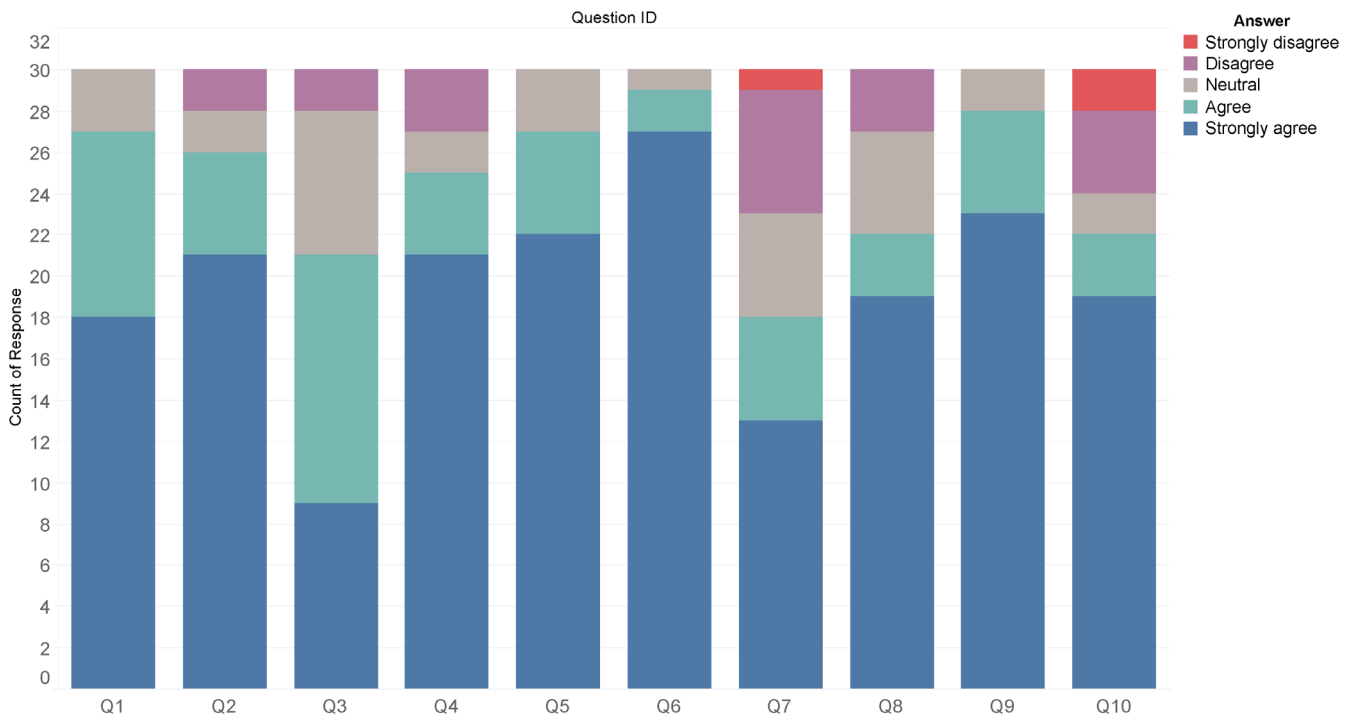


FIGURE 2 Distribution of participants' responses regarding different online case-based learning survey questions.

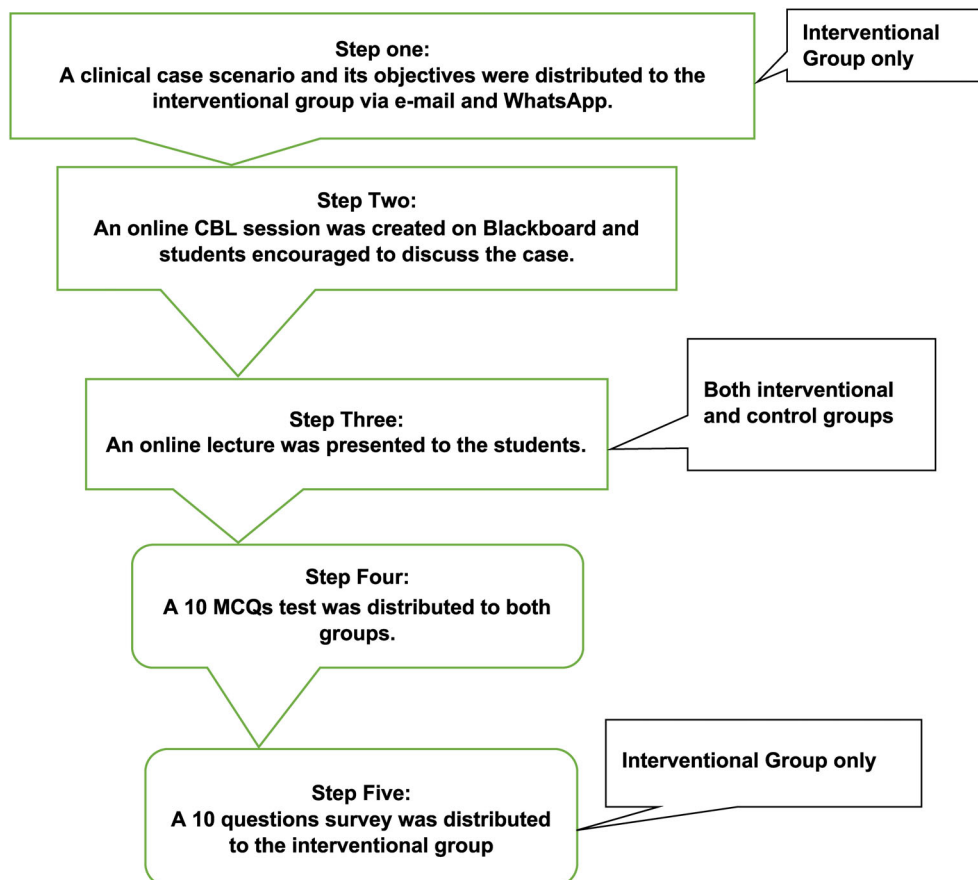


FIGURE 3 Schematic diagram representing the different steps that were carried out during the study regarding interventional and control groups.

TABLE 5 Grades of control and interventional groups in the test (out of 10).

Interventional group	Control group
10.00	1.00
8.00	9.00
6.00	9.00
4.00	8.00
10.00	10.00
9.00	7.00
8.00	5.00
2.00	4.00
9.00	8.00
8.00	5.00
10.00	8.00
9.00	8.00
9.00	7.00
6.00	7.00
8.00	0.00
8.00	1.00
9.00	10.00
8.00	0.00
9.00	0.00
8.00	6.00
8.00	5.00
8.00	5.00
8.00	3.00
9.00	10.00
10.00	5.00
7.00	8.00
7.00	5.00
3.00	7.00
8.00	5.00
9.00	5.00
5.00	4.00
8.00	2.00
9.00	5.00

Furthermore, integrated modules combining clinical and basic sciences were found to be a popular method of teaching, as shown in a study conducted by Christine A. Major et al.²⁰

A study performed in Punjab involving 94 medical students who were divided into two groups and taught pharmacology topics using CBL and didactic lectures showed no significant difference between the two methods ($p = 0.98$), which is in contrast to our results,

which showed a significant difference between the students who attended the online CBL session and the conventional lecture ($p < 0.001$); however, the same study revealed that there was a significant difference between the two groups regarding knowledge and problem-solving questions where the students who attended the CBL session performed better on cognitive questions compared to the other group.²¹

Similar results were confirmed in other studies in which the average scores increased significantly after CBL sessions, ranging between ($p = 0.004$) and ($p < 0.0001$).^{19,22}

Moreover, in a survey conducted among 3rd-year medical students at Al Quds University Medical School, Palestine, 84% of participants reported that team discussion in the CBL session had covered the intended lecture objectives, and 76.6% of the students strongly agreed that the online CBL session helped them understand the topic precisely.²³

It has also been reported that CBL increases self-oriented learning, critical thinking, and decision-making,¹⁷ which is consistent with our results, as 70% of students admitted that the session enhanced their problem-solving abilities.

In addition, a survey conducted by Gupta et al. showed that 76.09% of students found CBL sessions better than conventional lectures and tutorials, which was confirmed by our study, which reported that 73.3% of students either strongly agreed (63.3%) or agreed (10%) with this.²⁴

In a study conducted in the USA, many students (89%) preferred CBL in PBL; in our results, 73.3% of students preferred online CBL to conventional education.²⁵

In our survey, 73.3% of students found that online CBL was interesting, supporting other studies that stated that students enjoyed CBL sessions, which increased their learning ability.²⁶ Moreover, a survey conducted among postgraduate students of medical oncology confirmed that many students found CBL sessions interesting compared to conventional online lectures.²⁷

In addition, 70% of students admitted that online CBL increased their problem-solving abilities, which was confirmed by other surveys that found that CBL could promote students' critical thinking and problem-solving skills.^{28,29}

Additionally, the survey showed that 60% of students found that online CBL helped them communicate effectively with their classmates, whereas 23.3% did not agree with this idea. This was confirmed by another survey conducted among residents of China during the pandemic, which showed that 68.4% of respondents found that online sessions helped them communicate effectively.³⁰

5 | CONCLUSION

This study showed that CBL sessions can significantly improve the student's performance in exams compared to traditional methods of learning which indicates that it increased their understanding of the learned topic, in addition to that many students reported that CBL sessions increased their problem-solving ability and they found it more enjoyable and interesting than traditional methods of education. It is recommended that more advanced learning techniques such as CBL must be involved in basic sciences' education and to implement more e-learning techniques in universities.

6 | LIMITATIONS

The results of this study are limited by the small number of students, hence more studies are needed on online CBL to confirm the results.

AUTHOR CONTRIBUTIONS

Conceptualization: Eman A. Kubbara. *Data curation:* Eman A. Kubbara. *Formal analysis:* Turki Alamri. *Funding acquisition:* Eman A. Kubbara. *Investigation:* Rasha Eid, Abdulrahman Omer Alzahrani. *Methodology:* Turki Al Amri. *Project Administration:* Nasreldin Marhoum Ahmed. *Resources:* Rasha Eid, Abdulrahman Omer Alzahrani. *Software:* Turki Alamri. *Supervision:* Nasreldin Marhoum Ahmed. *Validation:* Marwan A. Bakarman. *Visualization:* Husam Malibary. *Writing – Original Draft Preparation:* Husam Malibary. *Writing – Review & Editing:* Marwan A. Bakarman.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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REFERENCES

- Manchia M, Gathier AW, Yapici-Eser H, Schmidt MV, de Quervain D, van Amelsvoort T, et al. The impact of the

prolonged COVID-19 pandemic on stress resilience and mental health: a critical review across waves. *Eur Neuropsychopharmacol.* 2022;55:22–83.

- Nayak J, Mishra M, Naik B, Swapnarekha H, Cengiz K, Shanmuganathan V. An impact study of COVID-19 on six different industries: automobile, energy and power, agriculture, education, travel and tourism and consumer electronics. *Expert Syst.* 2022;39(3):e12677.
- Hoofman J, Secord E. The effect of COVID-19 on education. *Pediatr Clin North Am.* 2021;68(5):1071–9.
- Mukhtar K, Javed K, Arooj M, Sethi A. Advantages, limitations and recommendations for online learning during COVID-19 pandemic era. *Pak J Med Sci.* 2020;36:S27–31.
- Herbert C, El Bolock A, Abdennadher S. How do you feel during the COVID-19 pandemic? A survey using psychological and linguistic self-report measures, and machine learning to investigate mental health, subjective experience, personality, and behaviour during the COVID-19 pandemic among university students. *BMC Psychol.* 2021;9(1):90.
- Alsoufi A, Alsuyihili A, Msherghi A, Elhadi A, Atiyah H, Ashini A, et al. Impact of the COVID-19 pandemic on medical education: medical students' knowledge, attitudes, and practices regarding electronic learning. *PLoS One.* 2020;15(11):e0242905.
- Giliyaru S, Hegde G, Gajjala S, Vemuri O, Azzopardi C, Hurley P, et al. COVID-19 pandemic and medical education. *Indian J Med Sci.* 2021;73(1):64–5.
- Chen SY, Lo HY, Hung SK. What is the impact of the COVID-19 pandemic on residency training: a systematic review and analysis. *BMC Med Educ.* 2021;21(1):618.
- Segbenya M, Bervell B, Minadzi VM, Somuah BA. Modelling the perspectives of distance education students towards online learning during COVID-19 pandemic. *Smart Learn Environ.* 2022;9(1):13.
- Karadag E, Su A, Ergin-Kocaturk H. Multi-level analyses of distance education capacity, faculty members' adaptation, and indicators of student satisfaction in higher education during COVID-19 pandemic. *Int J Educ Technol High Educ.* 2021;18(1):57.
- Salas-Pilco SZ, Yang Y, Zhang Z. Student engagement in online learning in Latin American higher education during the COVID-19 pandemic: a systematic review. *Br J Educ Technol.* 2022;53(3):593–619.
- Hu YH. Effects of the COVID-19 pandemic on the online learning behaviors of university students in Taiwan. *Educ Inf Technol (Dordr).* 2022;27(1):469–91.
- George PP, Papachristou N, Belisario JM, Wang W, Wark PA, Cotic Z, et al. Online eLearning for undergraduates in health professions: a systematic review of the impact on knowledge, skills, attitudes and satisfaction. *J Glob Health.* 2014;4(1):10406.
- Pei L, Wu H. Does online learning work better than offline learning in undergraduate medical education? A systematic review and meta-analysis. *Med Educ Online.* 2019;24(1):1666538.
- Burgess A, Matar E, Roberts C, Haq I, Wynter L, Singer J, et al. Scaffolding medical student knowledge and skills: team-based learning (TBL) and case-based learning (CBL). *BMC Med Educ.* 2021;21(1):238.
- Gartmeier M, Pfurtscheller T, Hapfelmeier A, Grünwald M, Häusler J, Seidel T, et al. Teacher questions and student

- responses in case-based learning: outcomes of a video study in medical education. *BMC Med Educ*. 2019;19(1):455.
17. McLean SF. Case-based learning and its application in medical and health-care fields: a review of worldwide literature. *J Med Educ Curric Dev*. 2016;3:S20377.
 18. Ali M, Han SC, Bilal HSM, Lee S, Kang MJY, Kang BH, et al. iCBLs: an interactive case-based learning system for medical education. *Int J Med Inform*. 2018;109:55–69.
 19. Nair SP, Shah T, Seth S, Pandit N, Shah GV. Case based learning: a method for better understanding of biochemistry in medical students. *J Clin Diagn Res*. 2013;7(8):1576–8.
 20. Major CA, Burnham KD, Brown KA, Lambert CD, Nordeen JM, Takaki LAK. Evaluation of an online case-based learning module that integrates basic and clinical sciences. *J Chiropr Educ*. 2021;35(2):192–8.
 21. Kaur G, Rehncy J, Kahal KS, Singh J, Sharma V, Matreja PS, et al. Case-based learning as an effective tool in teaching pharmacology to undergraduate medical students in a large group setting. *J Med Educ Curric Dev*. 2020;7:2382120520920640.
 22. McLean SF, Horn K, Tyroch AH. Case based review questions, review sessions, and call schedule type enhance knowledge gains in a surgical clerkship. *J Surg Educ*. 2013;70(1):68–75.
 23. Tayem YI. The impact of small group case-based learning on traditional pharmacology teaching. *Sultan Qaboos Univ Med J*. 2013;13(1):115–20.
 24. Gupta K, Arora S, Kaushal S. Modified case based learning: our experience with a new module for pharmacology undergraduate teaching. *Int J Appl Basic Med Res*. 2014;4(2):90–4.
 25. 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. *Acad Med*. 2007;82(1):74–82.
 26. 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. *Med Teach*. 2012;34(6):e421–44.
 27. Bi M, Zhao Z, Yang J, Wang Y. Comparison of case-based learning and traditional method in teaching postgraduate students of medical oncology. *Med Teach*. 2019;41(10):1124–8.
 28. Baumberger-Henry M. Cooperative learning and case study: does the combination improve students' perception of problem-solving and decision making skills? *Nurse Educ Today*. 2005; 25(3):238–46.
 29. Popil I. Promotion of critical thinking by using case studies as teaching method. *Nurse Educ Today*. 2011;31(2):204–7.
 30. Duan Y, Li Z, Wang X, Gao Z, Zhang H. Application of online case-based learning in the teaching of clinical anesthesia for residents during the COVID-19 epidemic. *BMC Med Educ*. 2021;21(1):609.

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