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Effect of virtual case-based learning (CBL) using the flipped class and peer instruction on the motivation to learn basic sciences

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Abstract

Background According to Self-Determination Theory, active learning methods, as alterations to the learning environment, can influence students' academic motivation to learn. The purpose of this quasi-experimental study was to investigate the effect of virtual case-based learning sessions on the learning motivation of first- and second-year medical students.

Methods A total of 258 students, 128 in the intervention group and 130 in the control group, were enrolled in the study. The control group consisted of medical students who had not previously participated in virtual case-based learning sessions and were trained in the same curriculum as the intervention group. Two questionnaires were created to evaluate learning motivation in basic science and the motivational outcomes of virtual case-based learning sessions, drawing on the three fundamental needs outlined in Self Determination Theory. The questionnaires were designed through individual interviews with students and validated using Lawshe's method and Cronbach's Alpha. The virtual case-based learning sessions were designed as a series of webinars on various topics, with students randomly divided into groups and assigned trained moderators. Clinical scenarios were designed by a team of basic scientists and clinical educators. Each virtual case-based discussion consisted of three phases and was completed in three days. Comparisons between two groups were made using the two-sample t-test and Pearson's correlation coefficient was used to analyze the motivational consequence questionnaire.

Results The results of the study indicated that virtual case-based learning sessions had a significant impact on the learning motivation of basic science students ($p < 0.01$). Additionally, the most notable motivational consequences of CBL sessions were basic sciences applicability and its interestingness.

Conclusions The study provides valuable insights into the effectiveness of virtual case-based learning sessions and suggests avenues for future research. The findings of this study could be useful for educators and institutions seeking to enhance the learning motivation of medical students through virtual case-based learning sessions. However,

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further research is needed to investigate the long-term effects of virtual case-based learning on student motivation and academic performance.

Keywords Case-based learning, Motivation, Medical students

Background

In December 2019, a new virus called COVID-19 was born and unexpectedly changed our lives. It affected all communities around the world in various aspects such as health issues, economy, and education. Education systems experienced an enforced revolution and the curriculum shifted towards e-learning [1]. These rapid changes, made medical students concerned about the effectiveness of this kind of learning for becoming a capable doctor [2]. As a result, these challenges affect their mental health and motivation as part of the psychological aspects of learning.

Motivation is the process that derives goal-directed activities and maintain them and could affect learning as both dependent and independent factor [3]. Studies have shown that teaching methods can influence learning motivation and academic performance especially the collaborative ones e.g. problem based learning, simulation-based learning and case-based learning [4]. For instance, Hayat and colleagues examined 370 medical students at Shiraz University of Medical Sciences and found that positive emotions and motivation can correlate with grade point average (GPA) as academic achievement [5]. An investigation on the influence of simulation-based learning (as a cooperative learning method which simulate the real condition for learners with important details to practice the activities in a safe environment) and motivation on learning performance demonstrated that the learning method could affect the learning performance and motivation is a mediator between them [6]. Gholami et al. used case-based learning (CBL) as an active learning method which provided medical cases for nursing students and discovered that CBL can significantly enhance learning motivation in comparison to lecture-based learning as a traditional learning method [7]. Similar experience in Pakistan revealed that CBL increase learning motivation by making an understanding of learned concepts [8]. Moon-Sook Yoo and colleagues investigated that CBL can improve student motivation compared to lectures [9]. In summary, it can be said that the use of these methods can give medical students back their lack of motivation during the pandemic.

Our research is grounded in the three fundamental needs outlined by Self-Determination Theory, which is essential for promoting intrinsic motivation [3]. This theory served as a framework for developing the questionnaires items. For instance, we emphasized Autonomy with items like “I do not rely solely on lecture notes and read more to learn basic science” and “I engage with

others (professors or students) to seek answers to my basic science questions,” reflecting the importance of self-directed learning in enhancing motivation. We also focused on competence, as many of our questionnaire items—such as “Learning basic science is essential to becoming a successful physician” and “Participating in CBL sessions helped me appreciate the practical applications of basic science in our future medical careers”—illustrate students’ aspirations to develop their skills and understanding, which are vital for nurturing a sense of competence. Finally, we addressed Relatedness, highlighting its social dimension through items like “Group discussions and collaborating to answer questions make me feel good” and “Interacting with peers in CBL sessions motivates me to learn,” underscoring the significance of peer interaction and a sense of belonging in enhancing motivation across both traditional and case-based learning environments.

To the best of our knowledge, there are various studies worldwide on the results of personal CBL. However, the motivational results of the virtual case-based learning method require an in-depth study. Therefore, the main purpose of the present study is to assess the motivational consequences of virtual case-based learning sessions (named facilitated CBL virtual course or FCVC) and learning motivation in basic sciences among first- and second-year medical students at Tehran University of Medical Sciences during the pandemic. In addition, a correlation analysis has been conducted to understand the association of motivational categories, resulting in positive correlation of the applicability and study motivation with the importance of basic science (BS).

Methods

Study participants

This quasi-experimental study included first- and second-year medical students of the Medical Faculty of Tehran University of Medical Sciences who participated in our program from 2019 to 2021. The total population was 258 students, 128 in the intervention group and 130 in the control group. The control group consisted of medical students who were trained in the same curriculum and had no prior experience of taking CBL courses. The ratio of women to men was 1:3 in both groups. The mean age of the intervention and control groups were 19.17 (SD=1.23) and 19.37 (SD=0.84) and the GPA of them were 18.33 (SD=0.76) and 17.85 (SD=0.99), respectively. The students took part in this survey voluntarily. Each participant was assigned a code to track and match the

Table 1 Items of learning motivation in Basic sciences Questionnaire

Question number	Item
1	I spend time on learning basic science.
2	Learning basic science is important in medical education.
3	I study basic science topics carefully
4	I participate in basic science classes.
5	Learning basic science is interesting.
6	Learning basic science is essential to become a successful physician.
7	I strive to understand the applications of basic science in medicine.
8	I participate in learning sessions based on case scenarios to appreciate the importance of basic science.
9	I do not rely solely on lecture notes and read more to learn basic science.
10	I enjoy discussing basic science topics with my friends.
11	I interact with others (professors or students) to find answers to my basic science questions.
12	Learning basic science makes me feel good.

Table 2 Items of Motivational consequences of virtual case-based Learning Sessions Questionnaire

Question number	Item
1	Participating in CBL sessions helped me understand that basic science topics are not transient.
2	Participating in CBL sessions helped me realize that basic science topics have practical applications in our future career as physicians.
3	Participating in CBL sessions motivated me to learn basic science topics more diligently.
4	Participating in CBL sessions helped me in paying attention to the application of basic science topics.
5	Participating in CBL sessions showed me that basic science is a very important level.
6	Participating in CBL sessions increased my interest in reading the scenarios available in reference books.
7	Participating in CBL sessions provided an opportunity for me to appreciate the value of basic science level.
8	Group discussions and learning basic science through CBL is interesting to me.
9	Group discussions and arriving at conclusions to answer questions make me feel good.
10	Interaction with peers in CBL sessions encourages me to learn.

questionnaires and address ethical issues. The study was approved by the Research Ethics Committees of School of Medicine, Tehran University of Medical Sciences (code: IR.TUMS.MEDICINE.REC.1400.844) and informed consent was obtained from all participants.

Questionnaire designing

Two questionnaires were developed; one to assess motivation to learn in basic science and the other to assess motivational consequence of virtual, case-based learning sessions consisted of 12 and 10 items, respectively (Tables 1 and 2). To determine the items of the questionnaires, individual semi-structured interviews three fundamental needs outlined by Self-Determination Theory, served as a framework for developing the questionnaires items. A targeted random sample was used. The sampling process continued until the data collected was a repeat of the previous one, and then the researchers reached data saturation. Therefore, 6 students who had experience of attending CBL sessions were interviewed. First, open-ended questions were asked about their motivation to learn, the importance of basic science, and their experiences and motivational consequences from CBL sessions. The follow-up interviews were conducted to clarify or verify the data and to improve the depth of the

data collected. All interviews were recorded. Each session lasted between 45 and 60 min on average. Finally, the data was analyzed using content analysis. To analyze the data, the interviews were transcribed verbatim, taking the context into account. The units of meaning were condensed into a description close to the text as manifest content and, as far as possible, into an interpretation of the underlying meaning as latent content. The condensed units of meaning were abstracted and called codes. The different codes were compared based on their differences and similarities and sorted into subcategories and categories. Finally, the items of the questionnaire were extracted from these categories.

After determining the validity of the questionnaire using Lawshe's method and determining the internal reliability of the instrument using Cronbach's Alpha, this questionnaire was distributed electronically to all participants. The response rate of Learning Motivation in Basic Sciences Questionnaire and the Questionnaire on Motivational Consequences of Virtual Case-Based Learning Sessions were 68.8% and 69.9%.

Intervention

The program was designed to be extra-curricular and was carried out as a series of webinars on various topics.

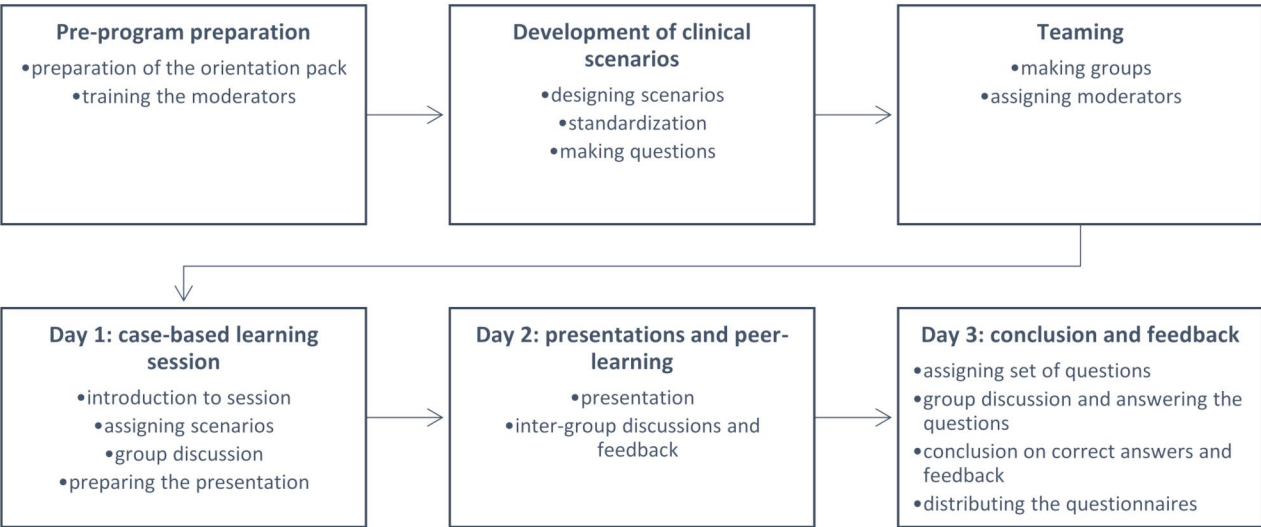


Diagram 1 The process of intervention

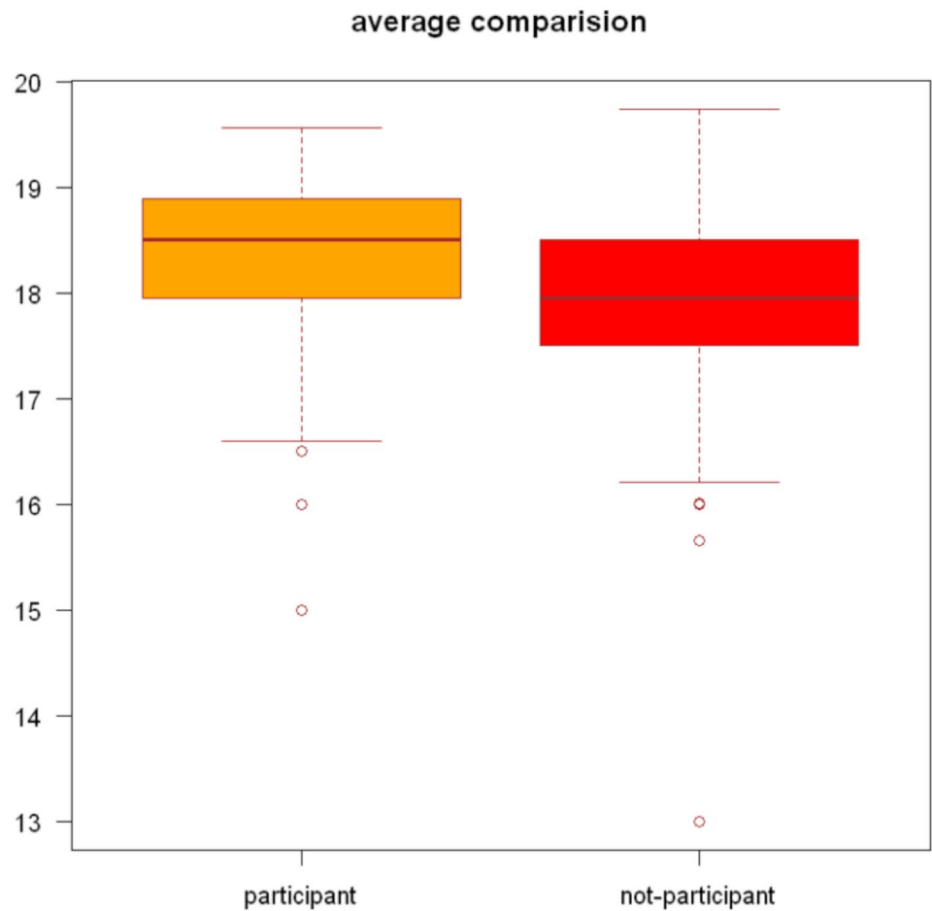


Fig. 1 Average of motivation score between participants and non-participants

First, an invitation to participate was announced and the students registered for the program. An orientation pack was prepared containing electronic content on the importance of teamwork, problem solving, clinical reasoning, the process of virtual case-based discussion, and an introduction to the Big Blue Button platform. The students were then randomly divided into teams of 5 to 7 students and each team was assigned a trained moderator. They were trained and coordinated with each other in terms of content and the necessary moderation skills. The facilitator training included a workshop full of group work, exercises and role play on facilitation skills. Clinical scenarios required for virtual case-based courses were designed by a team consisting of research team, basic scientists and clinical educators. We used twelve tips for writing a discussion case from David Cohen [10] to standardize the scenarios in our meetings with clinicians and basic scientists. For standard reassurance, the cases were reviewed and revised by five other teachers. Each virtual case-based discussion consisted of three phases and was completed in three days. **Day 1; case-based learning session:** Students were brought into a Big Blue Button room via a link. Big Blue Button or 3B is a free software web conferencing system and one of its core features is the creation of breakout rooms suitable for group collaboration. Each team, guided by their facilitator, discussed on a specific case that their learning goals were the same. They also discussed preparing the presentation of their teamwork report for the next day. In addition, a presentation frame was made available to the participants as a guide and the duration of the presentation and possible formats were determined. The group discussions lasted between 60 and 90 min in total. **Day 2; presentations and peer learning:** Each team had a maximum of 10 min to present the report of their discussion. After the presentation, the other teams could discuss, express their opinions and give feedback. The program duration differs depending on group discussions, varies between 60 and 120 min. **Day 3; conclusion:** A set of questions from the previous session was made available to all teams. The students then worked on these questions in small groups and the discussions were led by the moderators. Finally, the clinical and basic scientists summarized the cases and answered the students' questions. The session lasted about 120 min on average. After the session, the questionnaires in Google Form format were distributed to the participants and the non-participant group, which was selected from students of the same level not participating in FCVC.

Data analysis

Data analysis and charting were performed using Microsoft Excel and R dplyr package version 3.6.1 and Python version 3.9.11. All *p*-values were two-tailed and values

<0.05 were considered statistically significant. Comparisons between participants and non-participants were made using the two-sample *t*-test. The Shapiro-Wilk test was used to check the normality of the data. Pearson's correlation coefficient was used to assess the correlation between variables and to analyze the motivational consequence questionnaire.

Results

Two questionnaires were developed to evaluate the results. The Questionnaire on Learning Motivation in Basic Sciences and the Questionnaire on Motivational Consequences of Virtual Case-Based Learning Sessions contained 12 and 10 items, respectively. (Tables 1 and 2) The rating range was from 0 to 5 from strongly disagree to strongly agree. Cronbach's alpha for the learning motivation questionnaire and the motivational outcomes questionnaire of case-based learning sessions was calculated to be 0.92 and 0.89, respectively.

Of all 186 participants, 130 students filled out the questionnaire on the motivational consequences of the sessions. For the basic science learning motivation questionnaire, 128 students in the intervention and 130 in the control groups completed this questionnaire. Among the students who completed the motivational outcome questionnaire, there were 100 men and 30 women. The average age in this group is 19.13 with a standard deviation of 1.21. The average GPA is 18.33 with a standard deviation of 0.77.

In the group that completed the study motivation questionnaire, the mean age of the control and participant groups was 19.37 and 19.17 years, respectively, with a standard deviation of 0.84 and 1.23, respectively. The GPA was 17.85 and 18.33 with a standard deviation of 0.99 and 0.76, respectively (Fig. 1). About 75% of both groups were men. Seven virtual, case-based learning courses took place in the form of peer learning, as described in Table 3. In this study, 30 clinical scenarios were developed, and each scenario contained 3–4 questions. The level of learning motivation in basic science students participating in virtual case-based learning sessions and the control group was significantly different. (Table 4).

Figure 2 shows the motivational consequences of CBL among the participants. 75 participants totally agreed that the group discussion and getting results when answering the questions made them feel good (item 9: group discussion and finding the answer of the questions make me feel good.). They also agreed that these sessions made them realize that basic science is useful for their future careers as doctors. (73 people agree and 51 people strongly agree, item 2: CBL sessions showed me the application of basic sciences in my future career as a doctor.)

Table 3 Number of cases, facilitators, teams, and participants in virtual case-based learning session for undergraduate medical students

CBL Session	Number of scenarios used	Number of facilitators in each session	Number of teams	Number of participants
Cardiology CBL session	4	8	9	44
pulmonology CBL session	4	6	6	32
Gastroenterology CBL session	6	3	3	18
Endocrinology CBL session	6	4	4	24
Nephrology CBL session	2	4	4	28
Neurology CBL session	8	8	8	40

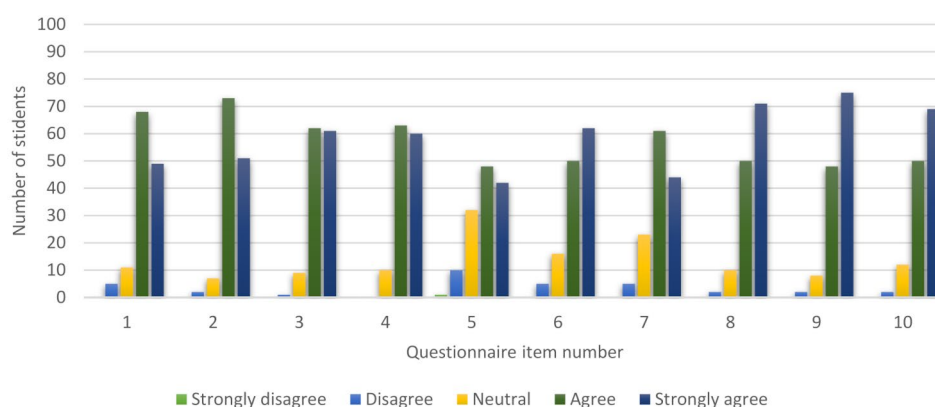
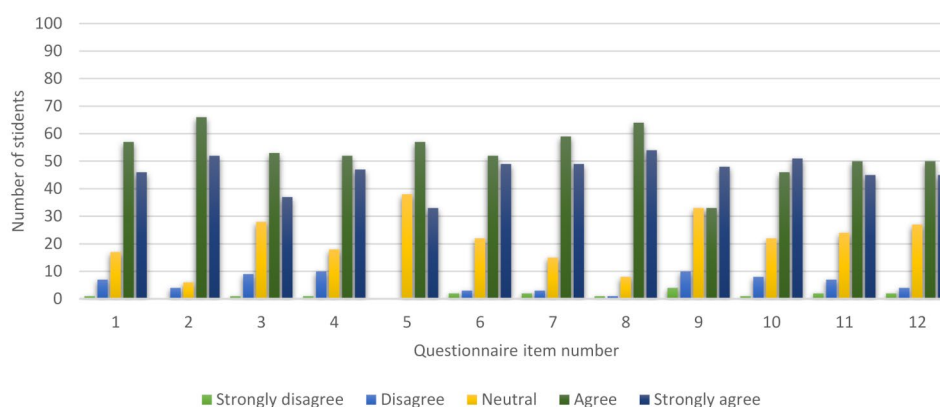
Table 4 Comparison of motivation to learn basic sciences in control and intervention groups in virtual case-based learning sessions

motivation to learn basic science	Mean	SD	Value	Degrees of freedom	P-value
Group of participants	4.08	0.14	10.195	16.461	0.01>
comparison group	3.19	0.27			

The basic science learning motivation of the participants is shown in Fig. 3 by element. 92% of the participating students believed that learning the basic sciences in medicine is important (52 people strongly agree and 66 people agree, item 2: learning the basic sciences in

medicine is important). 92% of them also said they attend CBL sessions to understand the importance of basic science. (54 people strongly agree and 64 people agree, item 8: I participate in CBL sessions in order to understand the importance of basic sciences.)

According to Fig. 4 and 62 of the non-participants stated that they do not try to learn more than what the educators teach them in the university courses. (25 people strongly disagree and 37 people disagree, item 9: I try to learn more than what the educators teach them in the university courses.) They also confirmed that they are trying to understand the application of basic science in medicine, although they have not attended CBL sessions.

**Fig. 2** Motivational consequences of CBL**Fig. 3** Basic science learning motivation of participants

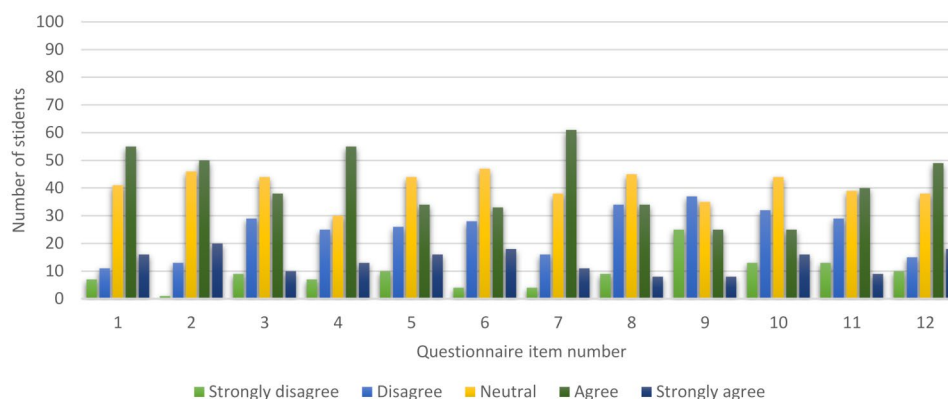


Fig. 4 Basic science learning motivation of non-participants

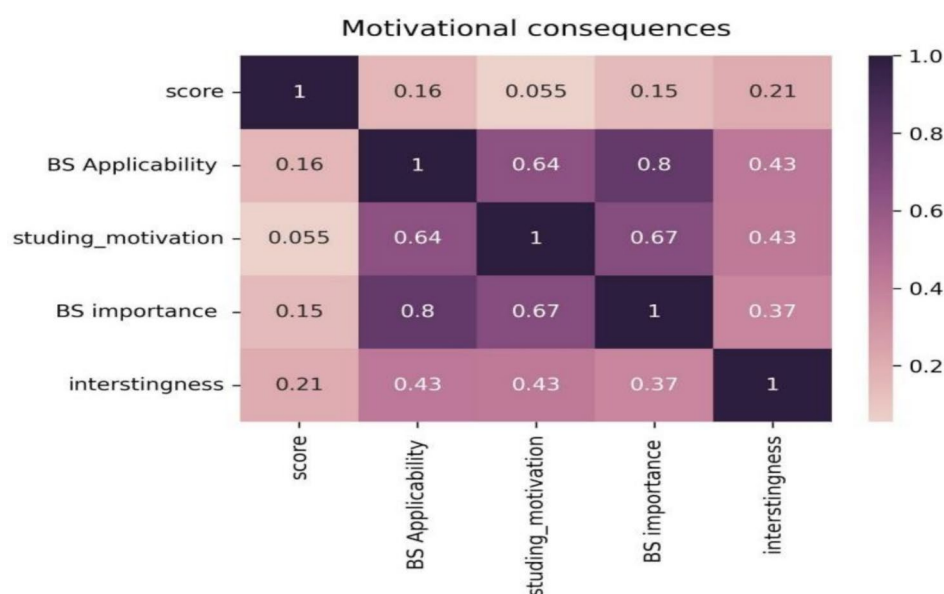


Table 5 The Pearson correlation table shows the correlation between the most differentiating predictors. The applicability and importance of BS correlate more closely with other predictors

(61 people agree, item 7: I try to find out the application of basic science in medicine.)

Pearson's correlation coefficient analysis showed a high positive correlation between the applicability and importance of BS. Study motivation correlated with BS importance. Interestingly, score shows the highest correlation with interestingness. (Table 5).

Discussion

The aim of the present study was to assess the motivational consequences of virtual case-based learning sessions among first- and second-year medical students at Tehran University of Medical Sciences during the pandemic. CBL teaching method, as novel teaching approaches, can develop students' abilities in various fields such as problem-solving, teamwork and higher-level thinking, promote self-learning and enhance the

sense of autonomy based on SDT [11, 12]. According to research conducted by McLean [13], CBL could range from simple knowledge gains to improving patient care outcomes. However, the motivational consequences of this method were not well defined. In this study, FCVC online course was used to assess the motivational consequences of combining CBL with flipped classroom in first- and second-year medical students during the COVID-19 pandemic, and to assess the motivation to learn basic sciences between participants and non-participants compare participants. In addition, a correlation analysis has been conducted to understand the association of motivational categories, resulting in positive correlation of the applicability and study motivation with the importance of BS.

The motivation to learn basic sciences was significantly higher among the participants of this course than among

the non-participants. It was estimated that they believed that the pre-clinical level and the basic sciences are important for future physicians. These results illustrate the potential of CBL and flipped classroom methods to fulfill three basic psychological needs outlined in Self-Determination Theory (SDT): autonomy (students' sense of control over their learning), competence (enhanced problem-solving and higher-level thinking abilities), and relatedness (collaboration and teamwork among peers), subsequently fostering a deeper motivation for learning basic sciences.

Similar results have been reported in other studies [8, 11, 14]. Baker's study showed that the problem-based learning method, as one of the subsets of case-based learning, encourages students to self-learning and increasing their sense of autonomy and helping to increase intrinsic motivation for learning [15]. A study at Khorramabad University has shown the effect of case-based sessions on the level of learning motivation and problem-solving skills of nursing students. Forty-five nursing students participated in this study and were divided into two groups; one group was trained using the lecture-based learning (LBL) method and the other group had CBL sessions for 6 weeks. Finally, it was found that the CBL method increased students' motivation to learn new things compared to the lecture method [11].

Based on the motivational questionnaire, the consequences are classified as follow parameters: (1) **BS applicability**: Participants understand the application of the basic sciences in the clinical setting and their future career as a doctor. Identifying the probable diagnosis of the scenarios, as well as explaining the pathophysiology of the diseases and their treatments based on their own limited knowledge, made clear to the participants the importance of basic science in medicine. The CBL method has been shown to effectively integrate and establish a link between basic science and clinical work [16, 17]. (2) **Studying motivation**: Participants were motivated to study more at their pre-clinical level as medical students. According to the findings of Raza et al. study [8], leads case-based learning to understanding of concepts learned in the classroom and development of skills in students and results in increased motivation to learn. Therefore, this outcome could likely be due to their recognition of the importance of learning basic science and their motivation to engage deeply in learning. (3) **BS importance**: Basic scientific knowledge that relates causal knowledge to disease symptoms can improve diagnostic accuracy [18]. It can also help to understand complex biological or physiological processes when encountering a patient with unknown symptoms and numerous co-morbidities, which illustrates the importance of BS in medical education [19]. Case-based learning could clarify the importance of learning the basic

sciences and encourage them to pay more attention to this topic. Recognizing the application of fundamental science in problem solving and in understanding the pathophysiology of disease can lead participants to discover this as important. As reported in the meta-analysis by Albanese and Mitchell [20], these types of learning methods could change participants' opinions about the preclinical level and its importance. (4) **Interestingness**: Participants were interested in the structure of the curriculum and learning in groups. Social distancing due to the COVID-19 era means education is only going in one direction – from professor to student; this has almost reduced student interaction and peer learning. Discussions in small groups helped the participants to better interact with like-minded people and made them feel good [21].

Conclusions

Based on the data provided, it can be concluded that virtual case-based learning sessions can have a significant impact on the learning motivation of basic science students. The study found that the level of learning motivation in students who participated in virtual case-based learning sessions was significantly higher than in the control group. Additionally, the high Cronbach's alpha values for both questionnaires indicate that they are reliable measures of learning motivation and motivational outcomes of virtual case-based learning sessions. These findings suggest that virtual case-based learning sessions can be an effective method for enhancing learning motivation in basic science students. However, further research is needed to investigate the long-term effects of virtual case-based learning on student motivation and academic performance.

Limitations and future research

This study was conducted at a single institution during the Covid-19 pandemic, a period characterized by a rapid transition from in-person lectures to online formats. As a result, our intervention represented a novel approach for students who had recently adapted to online learning environments. Consequently, the findings may not be applicable to other contexts where case-based sessions are a standard component of basic science education. It is possible that outcomes could differ if students possessed prior experience with such interactive sessions.

Another limitation of the current study is the reliance on researcher-developed questionnaires without assessing their construct validity. Future research should prioritize evaluating the construct validity of the tools used to ensure robust and reliable measurements. Additionally, expanding the study to multiple institutions and diverse educational settings could provide a broader

understanding of the motivational outcomes of case-based learning in basic science education.

Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s12909-024-06229-w>.

Supplementary Material 1

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Author contributions

A.A.T. contributed to the study concept, interpretation and drafting of the manuscript. A.S. contributed to the collection and data cleaning and interpretation of the manuscript. H.R. contributed to the study concept, statistical analysis, interpretation and drafting of the manuscript. A.T. contributed to data collection and cleaning. R.R. contributed to data collection and cleaning. S.S. contributed to data collection. Z.S.S. contributed to data collection and cleaning. S.P. contributed to data collection and questionnaires designing. A.Z. contributed to data collection and questionnaires designing. M.A. contributed to data collection, interpretation and drafting of the manuscript. All authors read and approved the final manuscript.

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Data availability

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval

The study was approved by the Research Ethics Committees of School of Medicine, Tehran University of Medical Sciences (code: IR.TUMS.MEDICINE.REC.1400.844) and informed consent was obtained from all participants.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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