BMC Medical Education

RESEARCH

Open Access

Effectiveness of the flipped classroom method using clinical scenarios and Educational Technology versus Subject-Based Lectures in a gastrointestinal physiology course for medical students

Masoumeh Seidi[1], Fatemeh Ramezani-Aliakbari[2*] and Amin Doosti-Irani[3]

Abstract

Background Medical education is evolving towards more practical, active, effective, and student-centered approaches that address the limitations of traditional lecture methods. Recently, the flipped classroom method has been considered to support these reforms. However, research on the use of flipped classroom methods in medical education, particularly related to clinical scenarios and educational technology, is still in its early stages. This study aims to evaluate the effectiveness of the flipped classroom method using clinical scenarios and educational technology versus subject-based lectures in the course of gastrointestinal physiology for medical students.

Methods A total of 60 medical students participated in this study. The control group ($n=30$) received traditional subject-based lectures and participated in question-and-answer sessions. The intervention group ($n=30$) received non-attendance educational content and participated in small group discussions based on clinical scenarios. Course satisfaction was measured using an 18-item questionnaire, and learning outcomes were assessed with a 20-question multiple-choice test, corresponding to levels 1 and 2 of Kirkpatrick's model. Data were analyzed using descriptive and analytical statistical tests with SPSS software version 24.

Results The findings indicated that the post-test scores in the intervention group were significantly higher compared to the control group. However, according to the student satisfaction questionnaire, satisfaction was significantly lower in the intervention group compared to the control group.

Conclusion This study demonstrated that the flipped classroom method, compared to traditional lectures, improved the learning and performance of medical students at Hamadan University of Medical Sciences in the course of gastrointestinal physiology.

Keywords Physiology, Clinical scenarios, Education, Flipped Classroom, Lecture

*Correspondence:
Fatemeh Ramezani-Aliakbari
f.ramezani@umsha.ac.ir
[1]Educational Development Center, Hamadan University of Medical Sciences, Hamadan, Iran
[2]Department of Physiology, School of medicine, Hamadan University of Medical Sciences, Hamadan, Iran
[3]Department of Epidemiology, School of Public Health, Hamadan University of Medical Sciences, Hamadan, Iran

Background

In medical education, integrating basic science content with clinical scenarios is a critical challenge for medical students who have little or no exposure to the clinical environment [1]. Therefore, it is necessary to integrate basic science with clinical science [2]. Another challenge in medical education that necessitates this integration is related to the meaningful and deep learning of medical students, as knowledge is most effective when applied [3]. Teaching basic sciences to medical students in line with clinical scenarios is the main approach. Integration can contribute to long-term retention and a more effective understanding of concepts among medical students. Clinical scenarios for medical students in the early years of training can help them understand the effective features of basic science concepts.

Students' lack of motivation and interest in theory-based classes, the lack of connection between basic courses and their future, and the lack of compatibility between basic and clinical sciences are among the most important challenges facing medical students. Integration can increase motivation and interest among medical students. It appears to be more pressing to offer practical classes for medical science students that adopt student-centered approaches. The physiology course is a basic course that is an important prerequisite for the pathology course. Students will have a better understanding of pathology if they have already learned the physiology course well. In addition, the practical part of physiology helps to understand the deep concepts and their applications. On the other hand, the lack of laboratory facilities and equipment in physiology laboratories in Iran will cause the practical part of physiology to be ignored, especially the topic of gastrointestinal physiology. Using traditional methods, not only is it difficult for students to understand the content and establish a connection between various subjects of basic sciences with clinical and applied sciences in the long term, but it also leads to reflections such as lack of motivation and apathy. Therefore, it is necessary that teachers of basic sciences, especially important subjects such as physiology, think of a solution to deal with these problems and negative attitudes, emphasizing the practical part of it.

Practical courses need more time for practice, but the existence of multiple units and the time limit in each academic semester deprive students of this opportunity. It is also necessary to prepare for events such as COVID-19. The COVID-19 pandemic and the shift to virtual learning have presented new challenges in implementing practical courses, resulting in traditional teaching methods failing to meet learners' educational needs. Medical education emphasizes facilitating deep learning among learners and promoting professional behavior in practical courses and skillful problem-solving [4]. In the current context, learners are surrounded by new technologies and have greater access to technology than in the past. The teaching approach could be improved by using the educational potential of these technologies and blending them with traditional teaching methods. This can lead to more effective teaching outcomes for practical lessons [5].

Eventually, the lack of necessary facilities to hold practical sessions on digestive physiology, the lack of time in each academic semester, students' lack of motivation and interest in theory-based classes, and the lack of deeper understanding among medical students are among the most important challenges facing medical students. A flipped classroom approach, which can be delivered virtually, has been demonstrated to produce superior learning effects compared to conventional teaching methods [6]. The application of the flipped classroom resulted in a positive attitude of the students towards the practical subject training course and increased their involvement and performance in the course [7]. More performance and satisfaction in students and faculty members are achieved by using virtual education [8]. The flipped classroom prioritizes and values the responsibility and autonomy of learners. This is achieved through independent and asynchronous study of class content, as well as active learning during scheduled class times [9]. Evidence proves the potential of flipped classes to promote students' behavioral and cognitive engagement [7]. Flipped classrooms promote learning motivation, understanding of the course materials, communication skills, and clinical thinking [10]. By implementing the flipped class method, the instruction could be switched from a teacher-centered to a student-centered approach. This method has different steps and provides a more interactive atmosphere in the class [11].

However, no research has been conducted on how clinical scenarios and educational technology can affect medical students. In flipped classroom research so far, discussions between students and teachers have occurred in a face-to-face setting in the class. However, the literature is limited in cases created with clinical scenarios in skill lab on mannequins while in a flipped classroom structure. In case of a lack of facilities and time for practical courses and a reduction of students' motivation, interest, and understanding of concepts, problems can be overcome by designing clinical scenarios and using multimedia methods such as videos, clips, and animations. Considering the importance of medical education and the role of the flipped class in improving the quality of education, as well as increasing the independence and role of the student, this study aimed to assess the effectiveness of the virtual flipped classroom learning method in the digestive physiology course. Specifically, for the first time, the present study aims to determine and compare the flipped classroom method using clinical

scenarios and educational technology versus subject-based lectures in the course of gastrointestinal physiology for medical students.

Methods

Study design and participants

This semi-experimental study employed a pre-test and post-test design with two groups: the intervention and the control. Sixty students from Hamadan University of Medical Sciences were included in the study through census sampling in the first half of the academic year 2023–2024. The study was conducted over eight sessions (six theory sessions, each 120 min, and two practical sessions, each 120 min) once a week, covering the Digestive Physiology course over eight weeks. The students were randomly divided into two groups of 30 each (Table 1). The groups were assigned based on even or odd numbers. Two course plans, designed according to the curriculum, were approved by the head of the department and the Medical Education Development Center of Hamadan University of Medical Sciences. The educational content, lecturer, and number of sessions were the same for both groups, with the professor also serving as the researcher.

Data collection and measurements

Control Group: The control group received subject-based lectures emphasizing content mastery and subject matter expertise, along with question-and-answer sessions. The six theory sessions (each 120 min) were conducted in the classroom. In the two practical sessions (each 120 min), a 30-minute lecture was followed by 90 min of practical learning on mannequins in the clinical skills center.

Intervention group

The intervention group was taught using the flipped classroom method and clinical scenarios in small group problem-solving sessions. The eight sessions included six theoretical sessions (each 120 min) in the classroom and two practical sessions (each 120 min) in the clinical skills center. The 30 students were randomly divided into five groups of six for group discussions.

Table 1 Characteristics of participants

Variables	Control group	Intervention group
Age	21.36 ± 2.30	20.76 ± 1.92
Gender		
Female	17	16
Male	13	14
Residence		
Hamadan	19	20
Other	11	10

Before class

For the six theoretical sessions, the teacher prepared educational videos and pamphlets, which were shared with students via Eitaa and Telegram. Students watched the videos and read the pamphlets at home.

During class

Each session began with a quiz of five FCQs to assess students' understanding. Scores were given to motivate and encourage study. A 20-minute mini-lecture was followed by a clinical scenario presented via video projector and handouts. Students discussed the scenario in small groups for 80 min, after which one or two groups were randomly selected to present their responses for 20 min.

Practical sessions

Educational video & clips were provided via Eitaa or Telegram before the sessions. In the clinical skills center, a quiz was conducted at the beginning, followed by 20 min of teacher-led training on mannequins. Students then practiced the techniques under supervision for 100 min.

After class

Knowledge and satisfaction were evaluated at the end of the last session using the questionnaire.

Student assessments included MCQs, observation with a checklist, self-evaluation, and peer evaluation.

Course evaluation

Knowledge was measured using a 20-question MCQ test based on the course content and educational objectives. Each correct answer received a score of 1, with a maximum score of 20. The knowledge questionnaire was developed and validated by three expert teachers and reviewed by the director of the physiology department and two medical education experts. Practical skills was evaluated by the professor using observation and a checklist.

Student satisfaction was measured using Talimkhani's satisfaction questionnaire with a Cronbach's alpha of 0.89 [12]. The 18-item questionnaire covered five areas: course content satisfaction, homework satisfaction, learning satisfaction, prepared content satisfaction, and total satisfaction. It used a 6-point Likert scale (completely satisfied (6), moderately satisfied (5), average (4), moderately dissatisfied (3), completely dissatisfied (2), and neither satisfied nor dissatisfied (1)), with scores ranging from 18 to 108. Both groups took a written pre-test at the beginning and a written post-test at the end of the course.

Data Analysis

The continuous variables were reported as mean and standard deviation (SD), the categorical variables were reported as frequency and percent. Paired t-test was

Table 2 Comparison of pre-test and post-test knowledge scores between groups in theoretical test

Group	Pre-test		Post-test		*P*-value
	Mean	SD	Mean	SD	
Control group	6.5	1.7	9.4	3.04	< 0.001
Intervention group	8	2.28	17.55	3.11	< 0.001

Paired t-test indicated average of scores in two experimental groups. Data are shown as mean ± SD

Table 3 Comparison of pre-test and post-test performance scores between groups in practical test

Group	Pre-test		Post-test		*P*-value
	Mean	SD	Mean	SD	
Control group	3.9	0.98	4.02	1.09	0.80
Intervention group	3.5	0.64	4.4	1.04	0.0002

Paired t-test indicated average of scores in two experimental groups. Data are shown as mean ± SD

Table 4 Students' satisfaction regarding in control and intervention groups

Satisfaction types	Control group	Intervention group	*P*-value
Course Content Satisfaction	43 ± 5.9	33.55 ± 7.77	< 0.001
Homework Satisfaction	21 ± 13.4	24 ± 5.9	0.319
Learning Satisfaction	5.3 ± 1.3	4.3 ± 1	0.001
Prepared Content Satisfaction	11.11 ± 1.36	9.03 ± 2.1	< 0.001
Total Satisfaction	85.44 ± 19.6	74.7 ± 16	0.028

T-test indicated average of scores in two experimental groups. Data are shown as mean ± SD

used to compare the mean scores pre and post-tests in each groups. T-test was used to compare the mean scores between intervention and control groups. The statistical significant level was considered as 0.05. Stata 17.01 (StataCorp, TX, US) was used for data analysis.

Results

The findings in Table 2 indicate a significant increase in the average post-test scores compared to the pre-test scores in both the intervention and control groups in the theoretical test. Moreover, the average scores in the pre-test and post-test of the intervention group showed a significant increase compared to the control group in the theoretical test. Medical students were randomly divided into the control and intervention groups, which could explain the significant difference in pre-test scores.

The findings in Table 3 indicated that, there is a significant increase in the average scores in the post-test compared to the pre-test in the intervention and the control groups in the practical test. Moreover, the average score in the pre-test in the intervention group showed a significant decrease compared with the control group in the practical test. The random division of medical students into two the control and the intervention groups can explain the significant difference in pre-test scores.

The total grade for gastrointestinal physiology for each item in the questionnaires was averaged and expressed as mean ± SD in Table 4. The average score for course content satisfaction in the intervention group (33.55 ± 7.77) showed a significant decrease compared to the control group (43 ± 5.9). Analyzing homework satisfaction revealed an increase in the average score in the intervention group (24 ± 5.9) compared to the control group (21 ± 13.4). Furthermore, the average scores for learning and prepared content satisfaction indicated a significant decrease in the intervention group (4.3 ± 1 and 9.03 ± 2.1, respectively) compared to the control group (5.3 ± 1.3 and 11.11 ± 1.36, respectively). Paired t-test analysis for total satisfaction (item five) revealed a significant reduction in the average score in the intervention group (74.7 ± 16) compared to the control group (85.44 ± 19.6).

Discussion

The primary goal of the educational system in medical fields is to achieve deep learning among learners, ensuring that the effects of education are evident in their future professional behavior. This study aimed to determine and compare of the flipped classroom method using clinical scenarios and educational technology versus subject-based lectures in the course of gastrointestinal physiology for medical students.

In terms of learning outcomes, researchers have shown higher post-test scores for medical students using the flipped classroom method compared to those learning from the subject-based lecture method. The improvement in students' grades demonstrates the effectiveness of flipped classroom teaching techniques, consistent with previous studies [13]. Many investigations have indicated that a flipped classroom is associated with effective learning, understanding, and retention of medical content [14, 15]. However, this study is unique because it extended the flipped classroom with clinical scenarios and the use of instructional technology.

In traditional lectures, students are often passive due to the lack of mechanisms to ensure intellectual engagement with the material. Additionally, students' attention wanes quickly after fifteen to twenty-five minutes [16]. The results align with previous studies that have shown the implementation of flipped learning as a promising teaching method [17]. The test effect shows the positive impact of recalling information on long-term memory retention [18], which is improved in the flipped classroom method. Evaluation post-test scores for the flipped classroom method are significantly higher than those for the traditional lecture method. Afrashtehfar et al. (2022) reviewed valid publications in the field of the flipped class and reported greater effectiveness of this method than the traditional one, especially for the highly collaborative

and technology-friendly population of the current student generation [19].

Students indicated that after studying the pre-presented course materials, discussing them in groups along with clinical scenarios, and solving them with the help of the teacher, they could remember the material for a long time and achieve a deeper understanding of basic and clinical science concepts. These results are consistent with the Ebbinghaus forgetting curve, which reports a direct relationship between memory and time [20]. Medical students take control and responsibility for their own learning in terms of subject mastery, study speed, and class attendance. They are also more receptive to critical thinking and are not afraid to solve their problems in such meetings. While actively participating in discussions and solving clinical scenarios in the flipped classroom, students can improve their levels in Bloom's taxonomy, such as application, analysis, and synthesis of knowledge, and achieve the ability to lead and work in a team.

In the traditional teaching method, the focus is on the subject rather than individual needs, limiting the understanding of concepts and solving clinical scenarios for each student. However, in the flipped classroom method, individualized and differentiated learning is enhanced by solving clinical scenarios and performing practical procedures. Students can focus their efforts and time on individual learning needs and future preparation. Therefore, they are not bored by class discussions and solving clinical scenarios that move too quickly or by class time spent covering material that has already been studied. This method can be effective for active students to learn course material in a short period and use the extra time to acquire psychomotor skills related to patient care [21].

In terms of practical skills outcomes, researchers have shown better practical skills for medical students using the flipped classroom method compared to students' skills from the subject-based lecture method in the course of gastrointestinal physiology. Practical learning is an important part of a medical student's professional development and extends throughout their career [22]. The primary goal of medical education is to produce specialists whose most important task is to treat patients [23]. The flipped classroom method helped improve the cognitive skills, psychomotor skills, and performance attitudes of medical students by creating more time and in-depth understanding of concepts, indicating that it is a reliable teaching method with a strong capacity to improve students' clinical performance. Moreover, students stated that in the flipped classroom method, they had more time to perform practical procedures in the skill lab, which helped promote their performance, individual needs, and self-confidence.

Laboratory courses are believed to play an important role in scientific theory courses by providing opportunities for students to acquire experimental skills and collaborative learning skills [10]. The use of technology-based learning has been a growing trend in education. A generation of medical sciences students who have come of age in the technology era are not only attracted to technology-based learning platforms but also demonstrate better objective learning compared to traditional modalities [24]. Despite better post-test scores in the intervention group, students' satisfaction in gastrointestinal physiology in the theoretical and practical sections was higher in the control group compared to the intervention group. Additionally, most students in the flipped classroom group stated that although this method was more useful, they felt stressed during the sessions and required more time to study and prepare for the exam in each session. Christopher (2018) found that students felt the flipped classroom model compounded their time pressure, with 75% agreeing that it meant they were spending more time on self-study. Of the students, 60% agreed that they liked the flexibility in their learning [11].

Along with our study, Tang (2022) used the flipped classroom method for teaching ophthalmology. According to his results, this method enhanced the learning motivation and communication skills of the learners. The post-test score of knowledge increased after the implementation of the flipped classroom. However, they reported that students did not prefer the flipped class to a lecture-based method. A previous study reported no effect on student satisfaction regarding the learning environment in the flipped classroom method [25]. However, a recent study indicated that the implementation of the active learning curriculum with the flipped classroom teaching method for the specialized field of pediatrics was successful according to their level of satisfaction [26]. DeLozier (2017) noted that other learning activities common in the flipped classroom (e.g., quizzes or clicker questions, pair-and-share activities, student presentations, and discussions) differ both in their effectiveness and in the conditions necessary for enhancing learning performance [27]. All medical students are completely familiar with the lecture method and are more satisfied with this method than the flipped classroom method. Therefore, they feel more comfortable during the lecture method compared to the flipped classroom method.

Generally, considering the enhancement of students' knowledge of the course, the implementation of blended learning using the flipped classroom method and group discussion with clinical scenarios and educational technology is suggested as one of the complementary methods for providing theoretical and practical lessons. Of course, this study was only conducted on a single course, and to generalize the results, more extensive studies are

required. However, the flipped classroom also has its limitations. Students often prefer traditional methods and expect the teacher to explain all the details. Additionally, students may not always complete the required homework before attending class [28]. The lack of control over students' mental and emotional conditions while completing the satisfaction questionnaire is another challenge faced in flipped classroom teaching.

Conclusions

The purpose of this study was to evaluate the effectiveness of the flipped classroom method using clinical scenarios and educational technology versus subject-based lectures in the course of gastrointestinal physiology for medical students. The implementation of the flipped classroom method, incorporating problem-solving in small groups, positively impacted students' learning. This teaching approach has the potential to enhance teaching effectiveness and could be implemented in similar courses. The study's findings indicate that students experienced significant improvements in knowledge and performance. Therefore, it is recommended that educators in various scientific disciplines consider employing this innovative teaching method to improve student learning outcomes. However, further studies with larger sample sizes are needed to provide stronger evidence of the intervention's effectiveness.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12909-024-05863-8.

Supplementary Material 1

Supplementary Material 2

Supplementary Material 3

Acknowledgements

This study is the result of research project number (14030114114) approved by Hamadan University of Medical Sciences. The researchers are very grateful for the cooperation of the esteemed Vice-Chancellor of Research and Technology of the University, Education Development Center, faculty members, and students of Hamadan University of Medical Sciences.

Author contributions

M.S., and F.R-A. designed the study. M.S., and F.R-A. were responsible for the double translation and cultural adaptation of the questionnaire. A.D-I. analysed the data and was the lead author of the manuscript. M.S., and F.R-A. contributed to discussing the analysis and drafting the manuscript. All authors contributed to the revisions and approved the final manuscript.

Funding

The research was supported by the Vice-Chancellor of Research and Technology of the University, Medical Education Development Center, faculty members, and students of Hamadan University of Medical Sciences.

Data availability

The data sets used and analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

Approval from the Hamadan University of Medical Sciences Human Ethics Committee for research on human subjects was obtained (Ethical code: IR.UMSHA.REC.2024.053). The study was conducted in accordance with the Declaration of Helsinki. In the first session, the research objectives were clarified for students, and they were assured of confidentiality and non-disclosure. Written informed consent was obtained.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Received: 9 June 2024 / Accepted: 2 August 2024
Published online: 09 August 2024

References

1. Brauer DG, Ferguson KJ. The integrated curriculum in medical education: AMEE Guide 96. Med Teach. 2015;37(4):312–22. https://doi.org/10.3109/0142159X.2014.970998.
2. Cassara M, DeVoe B, Fornari A, Kwiatkowski T, Gallo K. A description of the integration of interprofessional collaborative practice competencies in the first 100 weeks of medical student education. Med Sci Educ. 2014;24:333–8. https://doi.org/10.1007/s40670-014-0057-7.
3. Ambrose SA, Bridges MW, DiPietro M, Lovett MC, Norman MK. How learning works: seven research-based principles for smart teaching. Wiley; 2010.
4. Salehi Omran E, Salari Z. Blended learning a new approach in developing teaching and learning process. Educ Strategy Med Sci. 2012;5(1):69–75. http://edcbmj.ir/article-1-186-en.html.
5. Haghani F, Rezaei H, Eghbali B. Flipped classroom: a pedagogical method. Iran J Med Educ. 2016;16:104–19. http://ijme.mui.ac.ir/article-1-3971-en.html.
6. Cen X-Y, Hua Y, Niu S, Yu T. Application of case-based learning in medical student education: a meta-analysis. Eur Rev Med Pharmacol Sci. 2021;25(8). https://doi.org/10.26355/eurrev_202104_25726.
7. Taghipour K, Ghassemtabar SA. Effectiveness of flipped classroom in students' attitudes, Engagement, and performance in electronic content production lesson. J JMPR. 2021;16(62):123–35. 20.1001.1.27173852.1400.16.62.9.4.
8. Hew KF, Lo CK. Flipped classroom improves student learning in health professions education: a meta-analysis. BMC Med Educ. 2018;18:1–12. https://doi.org/10.1186/s12909-018-1144-z.
9. Evans L, Bosch MLV, Harrington S, Schoofs N, Coviak C. Flipping the classroom in health care higher education: a systematic review. Nurse Educ. 2019;44(2):74–8. https://doi.org/10.1097/NNE.0000000000000554.
10. Chen J, Zhou J, Wang Y, Qi G, Xia C, Mo G, et al. Blended learning in basic medical laboratory courses improves medical students' abilities in self-learning, understanding, and problem solving. Adv Physiol Educ. 2020;44(1):9–14. https://doi.org/10.1152/advan.00076.2019.
11. Christopher SV. Students' perceptions of a flipped classroom approach to paramedic theory. Br Paramed J. 2018;2(4):1–9. https://doi.org/10.29045/14784726.2018.03.2.4.1.
12. Talimkhani A. Virtual Flipped Classroom in Improving Undergraduate Physiotherapy Students' Satisfaction, Attitude, and Knowledge. IRUMSHAREC1399321 2020;Contract No: 9904312720.
13. Nouri J. The flipped classroom: for active, effective and increased learning–especially for low achievers. Int J Educ Technol High Educ. 2016;13:1–10. https://doi.org/10.1186/s41239-016-0032-z.
14. Kasat P, Deshmukh V, Muthiyan G, Gugapriya T, Sontakke B, Sorte SR, et al. The role of the flipped classroom method in short-term and long-term retention among undergraduate medical students of anatomy. Cureus. 2023;15(9). https://doi.org/10.7759/cureus.45021.
15. Vaddatti T, Chaitra B, Renuka I, Potti R. The perceptions of II MBBS Students toward flipped Classroom as an active method of learning. Dent Med Res. 2022;10(2):60–3. https://doi.org/10.4103/dmr.dmr_5_23.
16. Chimmalgi M. Interactive lecture in the dissection hall: transforming passive lecture into a dynamic learning experience. Anat Sci Educ. 2019;12(2):191–9. https://doi.org/10.1002/ase.1803.

17. Khoshsima H. The comparison of the use of data-driven learning in flipped, blended and conventional classes on students' grammar learning. JELTL. 2021;13(28):279–90. https://doi.org/10.22034/elt.2021.48829.2462.
18. Bertsch S, Pesta BJ, Wiscott R, McDaniel MA. The generation effect: a meta-analytic review. Mem Cognit. 2007;35:201–10. https://doi.org/10.3758/bf03193441.
19. Afrashtehfar K, Maatouk R, McCullagh A. Flipped classroom questions. Br Dent J. 2022;232(5):285. https://doi.org/10.1038/s41415-022-4042-z.
20. Bacon DR, Stewart KA. How fast do students forget what they learn in consumer behavior? A longitudinal study. J Mark Educ. 2006;28(3):181–92. https://doi.org/10.1177/0273475306291463.
21. Davies RS, Dean DL, Ball N. Flipping the classroom and instructional technology integration in a college-level information systems spreadsheet course. Educ Tech Res Dev. 2013;61:563–80.
22. Lakum NR, Maru AM, Algotar CG, Makwana HH. Objective structured practical examination (OSPE) as a Tool for the Formative Assessment of Practical Skills in the subject of physiology: a comparative cross-sectional analysis. Cureus. 2023;15(9). https://doi.org/10.7759/cureus.46104.
23. Desai KN, Satapara VK, Rathod GB, Maru AM. Development and evaluation of the POPBL (patient-Oriented problem-based learning) module in pathology: a comparative analysis of performance and perception among second-year pathology students. Cureus. 2022;14(9). https://doi.org/10.7759/cureus.28885.
24. Jones JW, Baumanis MM, Perryman M, Sykes KJ, Villwock MR, Cabrera-Muffly C, et al. Resident education in laryngeal stroboscopy: part II—evaluation of a multimedia training module. J Voice. 2021;35(5):772–8. https://doi.org/10.1016/j.jvoice.2019.12.026.
25. Van Alten DC, Phielix C, Janssen J, Kester L. Effects of flipping the classroom on learning outcomes and satisfaction: a meta-analysis. Educ Res Rev. 2019;28:100281. https://doi.org/10.1016/j.edurev.2019.05.003.
26. Moura IUEZd, Chakr VCBG. Online learning satisfaction and participation in flipped classroom and case-based learning for medical students. Rev Bras Educ Med. 2024;48(03):e087. https://doi.org/10.1590/1981-5271v48.3-2024-0004.
27. DeLozier SJ, Rhodes MG. Flipped classrooms: a review of key ideas and recommendations for practice. Educ Psychol Rev. 2017;29(1):141–51. https://doi.org/10.1007/s10648-015-9356-9.
28. Fisher R, Perényi A, Birdthistle N. The positive relationship between flipped and blended learning and student engagement, performance and satisfaction. Act Learn High Educ. 2021;22(2):97–113. https://doi.org/10.1177/146978741880170.

Publisher's Note