BMC Research Notes

RESEARCH NOTE

Open Access

Enhancing ophthalmology education through a mobile flipped classroom: a new teaching method

Maryam Yadgari[1], Masomeh Kalantarion[2,5*], Mohammad-Mehdi Sadoughi[3], Soleiman Ahmady[2] and Mohammad-Hasan Shahriari[4]

Abstract

Objective Glaucoma is a major cause of irreversible blindness globally. Optical coherence tomography (OCT) aids early glaucoma diagnosis. Interpreting OCT scans requires familiarity with the technology and image analysis. This study aimed to evaluate the effects of a mobile flipped classroom model on learning outcomes and satisfaction for teaching optical coherence tomography (OCT) interpretation skills in glaucoma.

Results In this quasi-experimental pre/post-test study, a total of 22 ophthalmology residents participated in a 4-session mobile flipped classroom educational intervention (90 min/session) and were assessed on OCT interpretation. Learning was measured via pre/post-tests designed by a panel. Satisfaction was assessed using a validated questionnaire. Mean participant age was 29.42 (± 2.09) years. Compared to pre-intervention, post-test scores showed significant improvement after the mobile flipped classroom ($p < 0.001$). Mean satisfaction score was 74.05 (± 16.09), denoting high satisfaction. Implementing a mobile flipped classroom significantly improved OCT interpretation skills and was associated with high satisfaction ratings among ophthalmology residents. This model shows promise for enhancing clinical knowledge in graduate medical education.

Keywords Optical coherence tomography interpretation, Ophthalmology residents, Teaching method

Introduction

Traditional didactic lectures in classrooms often lack effectiveness, as this passive method leads to superficial learning that is quickly forgotten [1]. As Boyer noted, prolonged lectures without active student engagement are highly ineffective [2]. In recent years, learners' needs, goals, and performance have evolved. Students now expect rapid access to information and prefer collaborative environments with learner-centered activities [3]. Advanced technologies, increased online content, and cognitive science have challenged traditional education approaches [3]. One method to transform teaching and incorporate online resources is the flipped classroom model [4].

*Correspondence:
Masomeh Kalantarion
kalantarion65@gmail.com
[1]Department of Ophthalmology, School of Medicine, Imam Hossein Hospital, Shahid Beheshti University of Medical Science, Tehran, Iran
[2]Department of Medical Education, School of Medical Education and Learning Technologies, Shahid Beheshti University of Medical Sciences, Tehran, Iran
[3]Ophthalmic Research Center, Research Institute for Ophthalmology and Vision Science, Shahid Beheshti University of Medical Sciences, Tehran, Iran
[4]Department of Health Information Technology and Management, School of Allied Medical Sciences, Shahid Beheshti University of Medical Sciences, Tehran, Iran
[5]Department of Medical Education, School of Medical Education and Learning Technologies, Shahid Beheshti University of Medical Sciences, Tehran, Iran

The flipped classroom flips traditional learning - content acquisition is done individually outside of class through video lectures, while interactive group activities occur in-class [5]. This emphasizes using pre-class educational videos for self-directed learning [6]. Learner's view content beforehand, so class time focuses on active application and workshops rather than passive listening [7].

In medical education, flipped classrooms have improved student satisfaction, academic performance, and outcomes across disciplines including medicine [8, 9], pharmacy [10], dentistry [11], and ophthalmology [12]. However, no studies have examined effects in ophthalmology assistants specifically.

Glaucoma is a major cause of irreversible blindness globally [13–15]. Optical coherence tomography (OCT) aids early glaucoma diagnosis through high-resolution cross-sectional imaging [15, 16]. However, interpreting OCT scans requires familiarity with the technology and image analysis. This study investigates the impact of a mobile flipped classroom model for teaching OCT interpretation in glaucoma on satisfaction among ophthalmology assistants. Flipped classroom approaches may provide an effective method to improve glaucoma education. We aim to provide insights that could guide improvements in educational content and delivery methods.

Methods

Study design and participants

This quasi-experimental pre-test/post-test study was conducted among ophthalmology residents at Shahid Beheshti University of Medical Sciences. A total of 22 residents (from years 1–3) were recruited through census sampling to expand the sample size. This sample size was limited by the number of available residents in the program; thus, future studies with a larger sample size and multiple sites would be ideal for broader applicability.

Inclusion and exclusion criteria's

Inclusion criteria were: interest in participating, and access to mobile devices. Exclusion criteria were: failure to complete questionnaires or tests, non-participation in the educational intervention, and stated inability to participate.

Instruments

The Educational Teaching Method Satisfaction Questionnaire (EMSQ) assessed learner satisfaction. This validated 10-item tool uses a 0–10 scale, with higher scores indicating greater satisfaction [17].

Pre- and post-tests evaluated glaucoma OCT interpretation knowledge. Tests were developed by a committee of 3 glaucoma specialists and 1 medical education expert [18–19]. The exam blueprint aligned questions with learning objectives (Table 1). Validity was established through expert review. Reliability (Kuder-Richardson 20 = 0.80) was determined during piloting.

Procedures

Sixteen modules focused on the interpretation of OCT for glaucoma cover a range of essential topics, including an introduction to various OCT devices, the significance of each device, their distinguishing features, and methodologies for interpreting the resulting images. Each module is designed to be interactive and incorporates multimedia elements such as instructional videos, case studies, and quizzes to enhance learner engagement and retention. All educational content is hosted on the web application OphthalMobilE (Ophthalmology Mobile Education), which provides a user-friendly interface for accessing materials (https://ophthalmobile.ir/). Access to this web application is free for all study participants, ensuring that they can easily engage with the content at their convenience. In addition to the core content, the modules include interactive features such as discussion forums and feedback mechanisms, allowing residents to ask questions and receive guidance from instructors in real-time.

After ethical approval and written consent, participants completed a pre-test on the study's mobile platform. The educational content was delivered through a series of structured modules that included both asynchronous learning materials accessed prior to class and synchronous in-class discussions. Sixteen glaucoma OCT interpretation modules were subsequently uploaded weekly over 4 sessions, each lasting 15 min. Learners accessed modules at least 6 days before each class session. In-class, case discussions reinforced module content. Groups investigated cases using module knowledge, presented findings, and received feedback. Post-tests occurred after

Table 1 Blueprint before and after the test

Number	Educational content	The number of questions related to each level of cognitive domain objectives					
		To create	To evaluate	To analyze	To apply	Understanding	Remembering
1	OCT Cirrus	-	-	6	4	3	3
2	OCT Optovue	-	-	3	3	2	2
3	OCT Topcon	-	-	3	3	2	2
4	OCT Spectralis	-	-	6	4	3	3

Table 2 Demographic data

		N	%
Sex	Male	10	(45.5%)
	Female	12	(54.5%)
Age	Mean ± SD	29.42 ± 2.09	
Years of assistantship	1	5	(23.8%)
	2	9	(42.9%)
	3	7	(33.3%)

each session, with the EMSQ administered at the end of the study period.

Data analysis

Quantitative analyses included means, standard deviations, frequencies, percentages, independent/paired t-tests, and ANOVA using SPSS v26. Significance was set at $p < 0.05$.

Ethics statement

The study was approved ethically. Informed consent was obtained. Participation was voluntary, data were anonymized, and confidentiality was maintained. This study was approved with ethical approved number IR.SBMU.SME.REC.1401.078 by the Ethic Committee of School of Medical Education and Learning Technologies, Shahid Beheshti University of Medical Sciences.

Results

Of the 22 participants, 10 (45.5%) were male and 12 (54.5%) females. Mean age was 29.42 ± 2.09 years (range 25–33). Most ($n = 14$, 63.6%) were single, with 8 (36.4%) married. By year, 9 (42.9%) were second-year residents, 5 (23.8%) first-year, and the remainder third-year (Table 2).

The mean overall satisfaction score on the EMSQ was 74.05 ± 16.9, indicating high satisfaction. Satisfaction was slightly higher among females (78.42 ± 17.53) versus males (68.8 ± 15.33), but not significantly different ($p = 0.191$) (Table 3).

By year, first-years had the highest satisfaction (79.4 ± 10.24) and third-years the lowest (71.43 ± 21.67), though not statistically significant ($p = 0.728$) (Table 4). Satisfaction was higher among single (76.71 ± 17.6) versus married (69.38 ± 15.59) participants, but the difference was not significant ($p = 0.339$).

The mean pre-test score was 8.84 ± 2.67 (range 3–16) and post-test was 11.67 ± 3.07 (range 4–16), a significant improvement ($p < 0.001$).

On the Cirrus OCT test, mean pre-test scores were 8.52 ± 2.71 (range 3–14) and post-test were 12.39 ± 2.71 (range 4–16), showing significant improvement ($p < 0.001$). On the Optovue OCT test, pre-test scores averaged 7.38 ± 1.6 (range 4–10) and post-test 8.86 ± 1.46 (range 5–10), also a significant increase ($p = 0.009$). For the Topcon OCT test, pre-test scores were 8.22 ± 1.2 (range 6–10) and post-test 9.36 ± 1.22 (range 6–10), a significant gain ($p = 0.004$). Finally, for the Spectralis OCT test, pre-test scores averaged 10.67 ± 2.9 (range 4–16) and post-test 13.65 ± 2.92 (range 4–16), again showing significant improvement ($p < 0.001$).

Pre-test scores were highest for Spectralis (10.67 ± 2.9) and lowest for Optovue (7.38 ± 1.6) ($p < 0.001$). Post-test scores were also highest for Spectralis (13.65 ± 2.92) and lowest for Optovue (8.86 ± 1.46) ($p < 0.001$) (Table 5).

Discussion

This study investigated the effectiveness of a mobile flipped classroom model on learning outcomes and satisfaction in OCT interpretation education for ophthalmology residents. The findings revealed significant improvements in test scores following the intervention. In summary, the educational approach notably enhanced OCT interpretation skills across all assessments, indicating that the mobile flipped classroom model is an effective strategy for advancing glaucoma education among ophthalmology residents.

Overall pre-test scores averaged 8.84 ± 2.67 and significantly improved to 11.67 ± 3.07 post-intervention ($p < 0.001$). These findings align with other research showing mobile flipped classrooms can enhance medical student learning in ophthalmology and other specialties [20–23].

The educational intervention also received high satisfaction ratings. The mean score on the learner satisfaction questionnaire was 74.05 ± 16.09, denoting

Table 3 Checking the level of satisfaction of ophthalmology assistants in general and by gender

		Sex		
P-value	Total number	Male	Female	
0.191	74.05 ± 16.9	68.8 ± 15.33	78.42 ± 17.53	Satisfaction score

Based on T-test

Table 4 Checking the level of satisfaction by academic year

	Years of assistantship			
P-value	1	2	3	
0.728	79.4 ± 10.24	72.67 ± 17.82	71.43 ± 21.67	Satisfaction score

Based on ANOVA

Table 5 Examining and comparing the score of each test before and after training in the mobile flipped classroom method

		OCT Cirrus 1	OCT Optovue 2	OCT Topcon 3	OCT-spectralis 4	*P*-Total	Pairwise comparison
Pre-test score	SD ± mean	8.52 ± 2.71	7.38 ± 1.6	8 ± 1.22	10.67 ± 2.9	< 0.001	(1,4 & 2,4 & 3, 4)
	Mode (range)	9(3,14)	8(4,10)	8(6,10)	11(4,16)		
	SD ± mean	12.39 ± 2.71	8.86 ± 1.46	9.36 ± 1.22	13.65 ± 2.92	< 0.001	(2,4 & 3,4 & 1,2 & 1,3)
Post-test score	Mode (range)	13(4,16)	9(5,10)	10(6,10)	15(4,16)		
P-Within		< 0.001	0.009	0.004	< 0.001		

Based on ANOVA (Multiple Comparison between groups based on Bonferroni)

participants were highly satisfied. Similar studies on flipped classrooms for physician continuing education likewise found increased satisfaction and engagement [22, 24–25].

While virtual platforms like mobile learning can improve access to materials, they may not fully replace traditional in-person teaching for clinical skills in ophthalmology [26]. This study combined mobile self-directed learning with face-to-face interactive case discussions. Blended approaches integrating technology with traditional methods are often most effective for medical education [27–29].

Regarding the use of multiple OCT devices, training on how to interpret OCT images for diagnosing glaucoma using the four devices is essential for ophthalmology residents for two main reasons: (1) All four devices are utilized across different hospitals in our country, and (2) While the functionality of these devices is similar, the methods of reading and interpreting their images differ significantly.

We emphasize that the inclusion of various OCT devices is a one of strength of our study. The positive impact of the flipped classroom teaching method was observed across all devices, demonstrating its effectiveness in training residents to use multiple OCT devices, even when taught simultaneously. Notably, the Spectralis device is more commonly used in academic centers, leading to greater access for assistants, which likely contributes to their higher scores compared to devices like Optovue. Understanding these differences can help improve educational content and approaches.

Gradually transitioning from teacher-centered to learner-centered approaches through blended learning models like the mobile flipped classroom warrants consideration in medical curricula. Future research should examine effects on long-term knowledge retention and clinical skill application. Study limitations include coordination challenges for scheduling participants. Nonetheless, results demonstrate the mobile flipped classroom's potential to significantly improve glaucoma OCT interpretation competency and satisfaction among ophthalmology trainees.

Further research with larger, multi-center samples is needed to increase generalizability. Randomized controlled trial designs comparing the flipped classroom to other teaching methods would provide higher quality evidence. Longitudinal follow up studies could evaluate long-term knowledge and skill retention. Qualitative studies could provide insights into participant experiences and perspectives. Comparative effectiveness studies on flipped classroom variants and integration with other educational technologies would help optimize learning. Finally, research on supporting learner access to mobile platforms and mitigating disparities warrants consideration given the increasing use of technology in medical education.

In summary, while this study demonstrates promising results, further rigorous research on mobile flipped classrooms in medical education can continue to inform implementation and best practices.

Limitations

This study has several limitations to consider. The small sample size from a single training program restricts the generalizability of the findings to broader populations. Additionally, the absence of long-term follow-up means that knowledge retention over time remains uncertain. The study design did not include a control group for comparison with the intervention, which limits our ability to attribute improvements solely to the educational approach. Furthermore, participant attitudes and satisfaction ratings may be influenced by response bias, which could affect the reliability of the reported outcomes. Lastly, scheduling challenges in coordinating participants were noted, which could be improved through enhanced communication and greater instructor availability.

Conclusions

This study implemented a mobile flipped classroom model for teaching OCT interpretation skills to ophthalmology residents and analyzed the effects on learning outcomes and satisfaction. Results demonstrated the educational intervention significantly improved test scores in OCT image analysis. Participants also reported high levels of satisfaction with the teaching method as reflected in the questionnaire responses.

These findings suggest that mobile flipped classrooms may be an effective approach for enhancing clinical knowledge and skills within ophthalmology training programs. The model integrates pre-class mobile self-directed learning with active, collaborative application of concepts through in-person case discussions. This blended approach is consistent with principles of active learning and learner-centered education.

Given the characteristics of today's learners, the implementation of flipped classroom designs warrants consideration in other medical education contexts beyond ophthalmology. However, further research is necessary to evaluate long-term knowledge retention, skill acquisition, and the comparative effectiveness of this approach relative to traditional curricula. As technology continues to evolve, exploring innovative integrations of emerging modalities with interactive in-person activities will be crucial for fostering engagement and clinical competency.

In conclusion, this study provides preliminary evidence supporting the benefits of a mobile flipped classroom in ophthalmology education. Continued research into optimal implementation strategies and learner-centered curricula will further enhance medical education to meet the evolving needs of 21st-century students and ultimately improve patient care.

Acknowledgements
The authors thank all of the residents who participated in this study.

Author contributions
MK and MY made a substantial contribution to the design of the research and prepared the initial manuscript. MK, SA, and MMS supervised the study and participated in collecting, analyzing the data, and proofreading the manuscript. MK, MY, and MHS Contributed to the writing of the manuscript and substantially revised the manuscript. Finally, all authors have read and approved the final manuscript.

Funding
This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Data availability
All data generated during this study are included in this published article.

Declarations

Ethics approval and consent to participate
Participants signed informed consent for inclusion in this investigation. All research procedures adhered to the Helsinki Declaration for Human Subjects and Good Clinical Practice guidelines. This study was approved by the Ethics Committee of the School of Medical Education and Learning Technologies, Shahid Beheshti University of Medical Sciences, under ethical approval number IR.SBMU.SME.REC.1401.078. Participants were provided with detailed information about the research's objectives and procedures prior to participation. Participants were also informed about the confidentiality of their responses, and their anonymity was strictly maintained throughout the study.

Consent for publication
Informed consent was obtained from all the ophthalmology residents involved in the study.

Competing interests
The authors declare no competing interests.

Received: 4 June 2024 / Accepted: 13 January 2025

Published online: 21 January 2025

References

1. Datig I, Ruswick C. Four quick flips: activities for the information literacy classroom. Coll Res Libr News. 2013;74(5):249–57.
2. Boyer A. The flipped classroom. TLN J. 2013;20(1):28–9.
3. Pierce R. *Student performance in a flipped class module*. in *Society for information technology & teacher education international conference*. 2013. Association for the Advancement of Computing in Education (AACE).
4. Horn MB. The transformational potential of flipped classrooms. Educ Next. 2013;13(3):78–9.
5. Lage MJ, Platt GJ, Treglia M. Inverting the classroom: a gateway to creating an inclusive learning environment. J Econ Educ. 2000;31(1):30–43.
6. Bishop J, Verleger MA. *The flipped classroom: A survey of the research*. in 2013 *ASEE Annual Conference & Exposition*. 2013.
7. Johnson G. Students, please turn to YouTube for your assignment. Educ Can. 2012;52(5):16–8.
8. Wong TH et al. Pharmacy students' performance and perceptions in a flipped teaching pilot on cardiac arrhythmias. Am J Pharm Educ, 2014. 78(10).
9. Park SE, Howell TH. Implementation of a flipped classroom educational model in a predoctoral dental course. J Dent Educ. 2015;79(5):563–70.
10. Tune JD, Sturek M, Basile DP. Flipped classroom model improves graduate student performance in cardiovascular, respiratory, and renal physiology. Adv Physiol Educ. 2013;37(4):316–20.
11. Ji M, et al. Short-and long-term influences of flipped classroom teaching in physiology course on medical students' learning effectiveness. Front Public Health. 2022;10:835810.
12. Succar T, et al. A systematic review of best practices in teaching ophthalmology to medical students. Surv Ophthalmol. 2016;61(1):83–94.
13. Barber W. *Building community in flipped classrooms: A narrative exploration of digital moments in online learning*. in *International Conference on e-Learning*. 2015. Academic Conferences International Limited.
14. Idrus RM. *The Mobile Learning Flipped Classroom*. in *Recent Advances in Education and Educational Technology, In proceedings of the 14th international conference on education and education technology (EDU'15), Kuala Lumpur, Malaysia, April 23*. 2015.
15. Schacknow PN, Samples JR. The glaucoma book: a practical, evidence-based approach to patient care. Springer Science & Business Media; 2010.
16. Stamper RL, Lieberman MF, Drake MV. Becker-Shaffer's diagnosis and therapy of the glaucomas E-Book. Elsevier Health Sciences; 2009.
17. Khoobi M, et al. A comparison of nursing students' satisfaction in compact disc-based education vs. traditional education. Iran J Med Educ. 2015;15:89–97.
18. Salkind NJ. Tests & measurement for people who (think they) hate tests & measurement. Sage; 2017.
19. Amin Z, Chong YS, Khoo HE. Practical guide to medical student assessment. World Scientific; 2006.
20. Tang F, et al. Comparison between flipped classroom and lecture-based classroom in ophthalmology clerkship. Med Educ Online. 2017;22(1):1395679.
21. Moghadam SM, et al. The Effect of web-based flipped Classroom Approach on learning and satisfaction of Medical Students comparison with lecture-based Method. Journal of Medical Education and Development; 2021.
22. Khoshnoodi Far M, et al. Comparison between the effects of flipped class and traditional methods of instruction on satisfaction, active participation, and learning level in a continuous medical education course for general practitioners. Sci J Kurdistan Univ Med Sci. 2019;24(1):56–65.
23. Fakhari E, et al. Process of the utilizing of flipped classroom for knowledge and satisfaction improvement of dental students in the periodontal and pediatric per clinical courses. J Med Spiritual Cultivation. 2017;26(3):213–8.
24. Gopalan C, Klann MC. The effect of flipped teaching combined with modified team-based learning on student performance in physiology. Adv Physiol Educ. 2017;41(3):363–7.
25. Diel RJ, et al. Flipped ophthalmology classroom augmented with case-based learning. Digit J Ophthalmology: DJO. 2021;27(1):1.
26. Sadoughi M-M, et al. Transforming ophthalmology training via mobile learning during the COVID-19 pandemic. J Ophthalmic Vis Res. 2021;16(4):698.
27. Shirzadegan R et al. Comparison of three methods of e-Learning, traditional and combined education on the Learning Health Assessment Lesson in Midwifery Students. J Nurs Educ (JNE), 2020. 9(5).

28. Nourian A, et al. Comparison of both virtual and traditional teaching methods in the teaching of theoretical community-oriented dentistry for Ph. D. students of Shahid Beheshti dentistry faculty of 2011– 2010. Volume 30. Journal of Dental School, Shahid Beheshti University of Medical Sciences,; 2012. pp. 174–83. 3.
29. Razavieh A, Fayazi M. An analysis of the effects of Internet on the Educatio-naand Research Data Acquisition Behavior of Universityl. J New Approaches Educational Adm. 2010;1(2):1–16.

Publisher's note