


Flipped Classroom Based on Outcomes-Based Education Improves Student Engagement and Clinical Analysis Competence in Undergraduates Ophthalmology Clerkship

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Objective: To investigate the effectiveness of flipped classrooms (FC) based on outcomes-based education (OBE) on clinical ophthalmology clerkships.

Methods: Ninety-nine undergraduates were non-randomly assigned to the FC based on the OBE (FC-OBE) group or traditional lecture (TL) group in the ophthalmology clerkship. Pre- and post-tests were performed to assess student learning outcomes. Anonymous questionnaires were collected to compare students' attitudes and classroom engagements between the two groups.

Results: More participants agreed FC-OBE was helpful in developing teamwork ability and knowing the work standard. Teaching staff in the FC-OBE classroom received higher evaluations. More participants in the FC-OBE group had higher classroom engagement in skills and emotions than in the TL group. The post-class test scores, mainly case analysis scores were higher in the FC-OBE group than in the TL group.

Conclusion: FC-OBE classroom improves student engagement and clinical analysis competence in undergraduate ophthalmology clerkship.

Keywords: ophthalmology education, OBE, flipped classroom, clinical clerkship, undergraduate

Background

Ophthalmic education in medical students is a cornerstone to improving eye health care globally.¹ In medical education, ophthalmology belongs to a more minor speciality, and the decreasing of ophthalmology curricular time has been a global trend.^{2,3} The literature from different countries assessing ophthalmology education shows low confidence in skills and knowledge topics of ophthalmology specialties in medical students.⁴⁻⁶ They represented the need for more ophthalmology teaching, significantly to improve clinical competence.^{7,8} Ophthalmic educators tried a variety of innovative and efficient teaching strategies to improve learning outcomes within a limited curricular time.⁹⁻¹¹

In China, ophthalmology education for five-year undergraduate medical students is about 25 class hours in total, of which 2/3 are used for classroom theory teaching and 1/3 are used for clinical clerkship. The course objectives include: mastering the basic ocular examination and the diagnosis and prevention knowledge of common diseases and frequently occurring diseases, understanding the performance of systemic diseases in the eye, and providing primary eye health care. Clinical clerkship in ophthalmology provides a valuable opportunity for medical students to develop their clinical core competence, including doctor-patient communication, clinical thinking, innovation and practical skills.^{12,13} An

important goal of clinical clerkship teaching is to improve student's clinical core competence. However, effective clinical instruction of medical students in ophthalmology is difficult.¹³

In recent years, the flipped classroom (FC) has become a popular teaching approach in medicine, nursing, and pharmacy education, because of the promise of enhancing student understanding of the material through active learning.¹⁴ However, the effects of the FC on learning are inconsistent, with some purported benefits^{15,16} and some reports of negligible improvement over traditional teaching methods.^{17,18} Existing literature showed that FC of ophthalmology has advantages over the traditional classroom,^{19,20} such as saving course time, higher student satisfaction, better course performance, and promoting active learning. Different from simply reading and memorizing theoretical knowledge in the traditional classroom, the student-centered curriculum design in the FC stimulates students to have a strong learning motivation, and actively acquire relevant knowledge to solve clinical problems. The main purpose of a clinical clerkship is to improve the ability of medical students to solve clinical problems. The advantages of FC in ophthalmology education are beneficial to achieve the goal of clinical clerkship.

The outcomes-based education (OBE) has been defined as

clearly focusing and organizing everything in an educational system around what is essential for all students to be able to do successfully at the end of their learning experiences.²¹

The core elements of OBE are the reverse curricular design, student-centred education and continuous improvement based on feedback. OBE is a performance-based and learner-centred approach to education offers a powerful and appealing way of reforming and managing medical education.²² OBE has been recommended in medical institutes around the world.²³ Outcome-based medical education differs from the framework of traditional lecture: (1) It emphasizes the acquisition of student's ability rather than the goal of the teacher's curriculum; (2) It has clear learning outcomes but flexible learning time. It is conducive to personalized learning to obtain the best performance; (3) Students are the main body and center of learning, and teachers are the guidance, which is consistent with the student-centered teaching design of the FC framework. Therefore, OBE can be integrated into FC design to improve students' learning initiative and core clinical competence in ophthalmology clinical clerkship.

Conjunctivitis is the most common eye disease and affects all ages and socioeconomic classes.²⁴ Conjunctivitis rarely causes permanent loss of vision but imposes largely economic and social burdens. A majority of conjunctivitis patients presented to their primary care physicians or emergency physician rather than an ophthalmologist.²⁵ Undergraduate medical students need to be familiar with the identification and treatment of common conjunctivitis and can make appropriate decisions for a timely referral to an ophthalmologist. Therefore, we choose conjunctivitis as the learning task for this study. In China, five-year undergraduate medical students have a 2-week clinical clerkship course in ophthalmology during the 6th semester. The outcomes of the ophthalmology clerkship are to develop undergraduate basic ophthalmology knowledge, clinical skills and provide appropriate primary eye care. Based on the outcomes, clinical clerkship was implemented based on the flipped classroom based on OBE or traditional lecture classroom, and the evaluation of student's attitudes, classroom engagements and performance were compared. This study was a preliminary observation of the effectiveness of the FC based on OBE in clinical ophthalmology clerkship for five-year undergraduates.

Materials and Methods

Ethical Approval

This study was approved by the Children's Hospital of Chongqing Medical University for the Education Teaching Research Project (No.EY202308) and exempt from approval by the Ethics Committee of the Children's Hospital of Chongqing Medical University, as it did not meet the criteria for human subjects research. All the contents of the study was performed by the Declaration of Helsinki. Informed consent was obtained from all participants.

Subjects and Study Design

This study is a single-centre, non-randomized, observational study. The Grade 2020 undergraduate of paediatrics at Chongqing Medical University was admitted to an ophthalmology clerkship at the Children's Hospital of Chongqing

Medical University. All participants completed 4-week basic theory courses in ophthalmology before clerkship, and they had not been exposed to clinical skills training in ophthalmology. These participants were non-randomized to the OBE +CBL classroom (OBE+CBL group, n=49) and the traditional lecture classroom (TL group, n=50) according to their small classes grouped in clinical clerkship.

Curriculum Design

We chose conjunctivitis as the learning task in this study. The outcome of this clinic clerkship includes: (1) identifying the clinical symptoms and signs of conjunctivitis; (2) mastering the clinical manifestations, diagnosis, differential diagnosis and therapy of bacterial, viral and allergic conjunctivitis. The flowchart of FC-OBE and TL classroom is summarized in Figure 1.

FC-OBE Classroom

Based on the core concept “student-centred, outcomes-oriented, and continuous improvement”, three-step flipped classroom was designed as follows: (1) pre-classroom activities: Teachers post learning objectives: (1) Identify the common symptoms and signs of conjunctivitis; (2) Understand the clinical manifestations and characteristics of common types of conjunctivitis (bacterial, viral and allergic conjunctivitis); (3) Diagnose and treat common types of conjunctivitis. Pictures and medical data of common types of conjunctivitis are provided online. Students prepare case reports according to basic theoretical courses and clinical data. The case report includes diagnosis, differential diagnosis, and treatment protocol. The student completes the above tasks and replies to the teacher. Learning feedback can encourage teachers to adjust the activity, and give more guidance to the learning difficulties and student’s ability shortcomings in class. (2) in-classroom activities: Students presented their case reports in a group unit of 5–6 persons. Teachers pay attention to observing the students’ learning status and answer questions to promote the cultivation of students’ clinical skill. The teacher instructed the students to identify the signs of conjunctivitis, including discharge, follicles and papillae, pseudo membrane and membrane, chemosis, and subconjunctival hemorrhage. Finally, the students summarize the clinical diagnosis and treatment framework under the guidance of the teacher. Specifically, the students can summarize the clinical characteristics of allergic conjunctivitis with redness, itching, chemosis, and redness. Students could identify bacterial conjunctivitis as characterized by purulent discharge, conjunctival congestion, eyelashes being stuck together in the morning, eyelid or conjunctival edema, and viral conjunctivitis as watery discharge, preauricular lymphadenopathy,

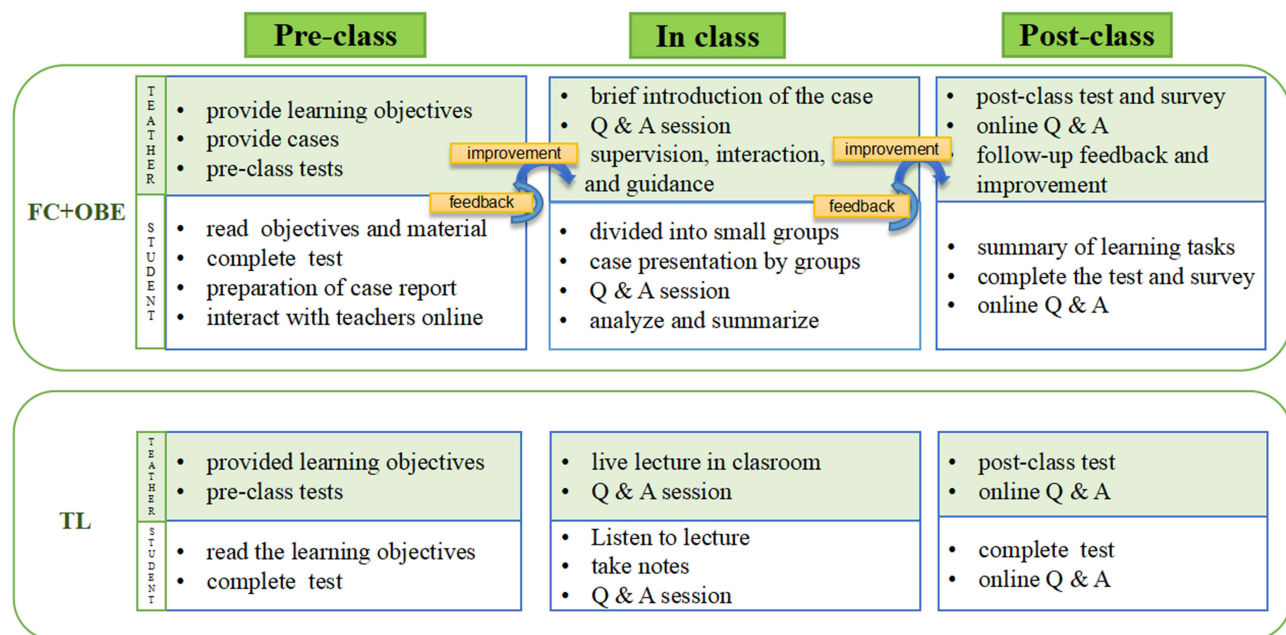


Figure 1 Flowchart of the FC-OBE and TL classroom.

acute follicles, superficial punctate keratitis, and pseudo membrane. (3) post-classroom activities: After class, carry out the evaluation of students' evaluation and tests. Students summarize the learning tasks. Teachers and students continue Q & A online. Teaching improvement is based on the teaching feedback of the previous link.

TL Classroom

Before the class, publish the learning objectives and content online. In class, a 40-minute traditional live lecture was given to the students through the PPT presentation, including the explanation and analysis of typical cases. The lecture attracts students through questions and discussions. After lecture, students ask questions and teachers answer questions for 20 minutes or feedback online.

Evaluation

Before the ophthalmology clerkship, all students completed a 10-question pre-class test for basic theoretical knowledge. After the class, the students completed the post-class test, including 5 case analysis questions and five basic theory questions. Finally, all students filled out a survey anonymously, using a 5-point Likert scale (1, strongly disagree; 2, disagree; 3, neutral; 4, agree; 5, strongly agree). This survey was modified by the Course Evaluation Questionnaire (CEQ) and the Classroom Engagement Survey (CES). Its construct validity was established from previous studies involving undergraduate nursing and medical students,^{26,27} obtaining high reliability.

Statistical Analysis

All the continuous variables were analyzed using an independent *t*-test. The categorical variables were analyzed by the chi-square test. All preliminary statistical analyses were performed using the SPSS 20.0 version (Chicago, USA). P-values of less than 0.05 were considered statistically significant.

Results

A total of 99 students were enrolled in the study, including 49 students in the FC-OBE group and 50 students in the TL group. There was no statistical difference in age and sex between the two groups ($P>0.05$). The details of the demographic characteristics of the participants were shown in Table 1. The pre-class test scores were 84.55 ± 1.12 in the FC-OBE group and 83.20 ± 1.25 in the TL group, respectively, with no statistical difference ($P>0.05$, Table 1).

Course Evaluation

Students' attitudes and satisfaction with the course was evaluated by the modified CEQ questionnaire. As shown in Table 2, participants in both groups considered that the course was not heavy, with no difference between groups ($P>0.05$). Participants agreed that the FC-OBE classroom was more helpful in developing ability to work as a team member (4.47 ± 0.11) than the TL classroom (4.02 ± 0.10) ($P<0.01$). More participants in the FC-OBE group considered it is easy to know the standard of work (4.49 ± 0.08) than in the TL group (3.94 ± 0.10) ($P<0.01$). Participants agreed that teaching staff in the FC-OBE classroom (4.63 ± 0.07) make their subjects more interesting than in the TL classroom (4.26 ± 0.09) ($P<0.01$). More participants in FC-OBE group (4.63 ± 0.07) agreed that teaching staff put a lot of time into commenting on students work, compared to the TL group (4.24 ± 0.09) ($P<0.01$).

Table 1 Demographic Characteristics of the Study Participants

	FC-OBE Group (n=49)	TL Group (n=50)	t/ χ^2	P
Sex				
Male	14	16	0.14	0.71
Female	35	34		
Age (years)	20.84 ± 0.11	20.90 ± 0.10	0.41	0.68
Pre-class test	84.55 ± 1.12	83.20 ± 1.25	0.81	0.42

Table 2 The Modified Course Evaluation Questionnaire (CEQ) in the Two Group Students

	FC-OBE Group (n=49)	TL Group (n=50)	t	P
The course helped me to develop my ability to work as a team member	4.47±0.11	4.02±0.10	3.02	0.00**
The work was too heavy	2.80±0.15	2.62±0.12	0.91	0.37
It is always easy here to know the standard of work expected	4.49±0.08	3.94±0.10	4.32	0.00**
Teaching staff here work hard to make their subjects interesting	4.63±0.07	4.26±0.09	3.19	0.00**
Staff here put a lot of time into commenting on students work	4.63±0.07	4.24±0.09	3.38	0.00**

Notes: This survey adopted a five-point Likert-type scale (1, strongly disagree; 2, disagree; 3, neutral; 4, agree; 5, strongly agree). Values are means ± SD. **Indicates P < 0.01. Adapted with permission from Broomfield D, Bligh J. An evaluation of the 'short form' course experience questionnaire with medical students. *Med Educ.* 1998;32(4):367–369.²⁶

Table 3 The Modified Classroom Engagement Survey (CES) in the Two Group Students

	FC-OBE Group (n=49)	TL Group (n=50)	t	P
Skills				
I can look over class notes between classes to make sure I understand the material	4.51±0.08	4.04±0.09	3.73	0.00**
Emotion				
It is important to obtain knowledge and develop techniques	4.39±0.09	4.10±0.09	2.29	0.02*
Performance				
I am good at the curriculum	3.98±0.10	3.72±0.10	1.78	0.08
I always do well on the tests	3.53±0.12	3.44±0.11	0.57	0.57
I am confident that I can learn and do well in the curriculum.	3.92±0.11	3.72±0.10	1.33	0.19
I do my best to get a good grade in the curriculum	4.25±0.10	4.08±0.09	1.21	0.23
Interaction				
I always participate actively in small-group discussions	4.10±0.11	4.00±0.08	0.75	0.46
I am glad to answer questions teacher proposed in class	3.94±0.11	3.76±0.10	1.21	0.23
I always take the initiative in asking questions when I do not understand the instructor	3.76±0.11	3.62±0.11	0.86	0.39

Notes: This survey adopted a five-point Likert-type scale (1, strongly disagree; 2, disagree; 3, neutral; 4, agree; 5, strongly agree). Values are means ± SD. *Indicates P < 0.05, **Indicates P < 0.01. Adapted with permission from Lin SH, Huang YC. Assessing college student engagement: development and validation of the student course engagement scale. *J Psychoeducat Assess.* 2017;36(7):073428291769761.²⁷

Classroom Engagement

Student classroom engagement was assessed through the modified Classroom Engagement Survey (CES). Participants in the FC-OBE group had higher scores (4.51±0.08) in the “skills engagement” item “I can look over class notes between classes to make sure I understand the material” than in the TL group (4.04±0.09) (P<0.001). In addition, participants in the FC-OBE group had higher scores (4.39±0.09) in the “emotional engagement” item “It is important to obtain knowledge and develop techniques” than those in the TL group (4.10±0.09) (P<0.05). There was no statistically significant difference in the “performance engagement” and “interaction engagement” between the two groups, and the details are shown in Table 3.

The Outcome of Clinical Ophthalmology Clerkship

Post-class tests including theoretical knowledge and case analysis were used to assess the outcome of clinical ophthalmology clerkship. The total score in the FC-OBE group (85.41±0.70) was higher than that in the TL group (82.84±0.83) (P<0.05). There was no difference in the theoretical knowledge scores between the two groups. However, participants in the FC-OBE group had higher scores of case analysis than those in the TL group (Figure 2).

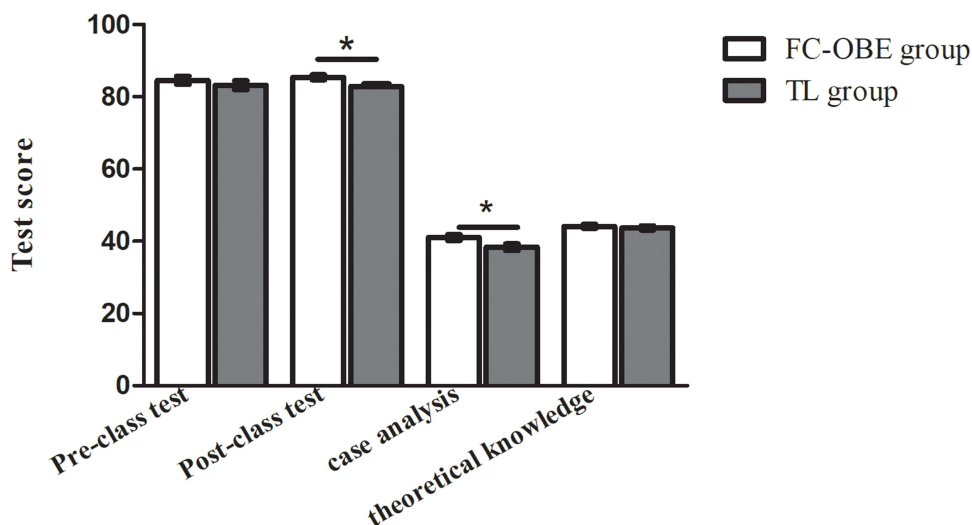


Figure 2 The pre- and post-class test scores between the FC-OBE and TL groups. *Indicates $P < 0.05$.

Discussion

This non-randomized, single-centre, observational study demonstrated FC based on OBE was an effective approach in clinical ophthalmology clerkship for five-year undergraduates. Firstly, participants agreed FC-OBE was more helpful in knowing learning tasks and team ability development than TL. Secondly, participants showed higher skill and emotional engagement in the FC-OBE classroom. They made higher evaluations of teaching staff in the FC-OBE. Lastly, learning outcomes assessed by post-class tests suggested that FC-OBE performed better than TL, especially in case analysis.

Outcome-based education (OBE) was propounded by William Spady in the 1990s,²⁸ defined as

clearly focusing and organizing everything in an educational system around what is essential for all students to be able to do successfully at the end of their learning experiences.²³

OBE brings the focus of education to what the students learn rather than what they were taught, shifting the “teacher-oriented” mode to the “student-led” mode. Flipped classroom provides students with opportunities to acquire lower-order cognitive abilities such as memory and comprehension during pre-class preparation, and uses valuable face-to-face classroom time to develop higher-order cognitive abilities including application, analysis, evaluation, and creation of described categorized cognitive domains.¹⁹ In this study, we attempted to create an effective ophthalmology clerkship course through flipped classroom based on OBE.

In this study, participants agreed FC-OBE was more helpful in knowing learning tasks than TL. The outcome of the OBE was described as “what students actually can do with what they know and understand”, basically involving “actual Results of learning that students visibly demonstrate”.²⁹ Before the class, students can have clear goals and plans according to the learning goals and materials online. Based on learning outcomes and pre-class feedback, the reverse design classroom enables students to be more actively participate in the learning process, such as case analysis and clinical application of theoretical knowledge under clear learning goals. The incorporation of more attractive student-centred teaching strategies of the flipped classroom requires the active participation of learners and engages learners in the process.³⁰ In addition, participants agreed the FC-OBE classroom was more helpful in developing the ability to teamwork than the TL classroom. Both FC and OBE “student-centred” models. In this learning environment, students play multiple roles, including the team organizer, participants, group moderator, and communicator of clinical cases and learning materials.

Evaluating students’ satisfaction may be subjective but it is important in any course or training evaluation as students are regarded as the primary stakeholder, whose satisfaction is one of the important quality indicators of education.³¹ In this study, staff evaluation in the modified CEQ was used to assess students’ satisfaction. Teaching staff in the FC-OBE

classroom received higher evaluations. There are two main reasons for the results. Firstly, in FC-OBE classes, teachers have made a role shift, who are the organization and facilitators of classroom activities, not just knowledge instructors in TL. One important new role for teaching staff is that of being an assessor, in keeping with the heightened priority of comprehensive and in-depth assessment of learning outcomes.²⁹ Continuous improvement in OBE is another reason why teachers receive high evaluations. In FC-OBE, teachers are required to be the supervisors and communicators of learning²⁹ and need to improve their teaching strategies according to the feedback from the students in each activity.³²

Student classroom engagement refers to students' cognitive investment, active participation, and emotional engagement with specific learning tasks, associated with high-quality learning outcomes.³³ The current study showed participants in the FC-OBE classroom had higher skills and emotional engagement than those in the TL group. Skills engagement refers to the learning strategies or practice skills that students adopt to do well in the classroom.³⁴ In FC-OBE, students prepared for the material by completing and reviewing all assigned pre-class. In class, students respond positively to learning tasks as active participants in FC-OBE, different from the passive role in the traditional classroom.³⁵ Emotional engagement refers to the affective states or responses of students when interacting with class material or learning environment. The most effective approach to improve teaching efficiency is to promote active learning, which requires students to actively engage with learning materials, and participate in the class. In FC-OBE, after obtaining clear learning objectives and pre-class learning materials, students can choose the time, place, frequency and way to learn independently and develop a better understanding of learning outcomes.³⁶ In-class activities were improved through pre-class feedback, and FC-OBE was designed as an interactive and student-centred environment which provided a greater opportunity to apply the learned concepts into practice.^{37,38}

Learning outcomes assessed by post-class tests suggested that FC-OBE performed better than TL, especially in case analysis. There was no difference in the course burden between the two groups. The ophthalmology clerkship plays an excessive role in preclinical medical education designed to develop medical students in teamwork, clinical reasoning, problem-solving, and mentoring.³⁹ An important outcome of the clerkship is the ability to analyze clinical cases, including diagnosis, differential diagnosis and feasible treatment plans.¹³ In FC-OBE class, students were clear about the outcomes before class. They obtained cases data and analyzed it, so they have more opportunities to think critically and actively. Then, the feedback from students promoted continuous improvement in classroom activities. Students lead teaching activities through independent thinking, group Discussion, representative reporting and communication. The role of teacher faculty is a facilitator of learning by stimulating creativity, self-learning, and critical thinking.²⁹ Teaching staffs put forward personalized guidance to help students gain the outcome of making the appropriate diagnosis and treatment of clinical cases.

Limitations

This study provides a preliminary observation of the FC-OBE approach in clinical ophthalmology clerkship for five-year undergraduates, but it has several Limitations. First, we only implement the FC-OBE in one 4-hour clerkship course. The course evaluation and learning outcomes confirm the effectiveness of short-term results. The effect of this model on other majors and long-term learning outcomes needs to be further implemented. Second, this study was a non-randomized controlled design. A selection bias may exist because of the non-random design. Considering that there was no difference in gender, age and pre-class test between the two groups, so we believed that the baseline level of participants in the two groups was comparable. Third, this study did not analyze teacher input costs (time, effort, stress, etc.), so the cost versus benefits is not clear. The next step is to explore the effectiveness of this approach in other ophthalmology clerkship courses with randomized control and large samples.

Conclusion

Despite these limitations, findings from this preliminary study suggest that the FC-OBE classroom improves student engagement and clinical analysis competence in undergraduate ophthalmology clerkship. Further study will evaluate the input cost and work pressure of the teaching staff to evaluate the cost-benefit ratio of this innovative approach.

Abbreviations

FC, flipped classroom; OBE, outcomes-based education; TL, traditional lecture.

Data Sharing Statement

The data are available from the corresponding author on reasonable request.

Ethics Approval and Consent to Participate

This study was approved by the Children's Hospital of Chongqing Medical University for the Education Teaching Research Project (No.EY202308), which has been exempted from ethical approval by the Ethics Committee of the Children's Hospital of Chongqing Medical University and was performed in accordance with the Declaration of Helsinki. Informed consent was obtained from all participants.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Funding

This work was supported by the Education Teaching Research Project in the Children's Hospital of Chongqing Medical University (No.EY202308).

Disclosure

Qing Liu and Xiao-Jiao Tang are co-first authors for this study. The authors report no potential conflicts of interest in this work.

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