



Flipped classroom approach to ophthalmology clerkship courses for Chinese students of eight-year program

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Background: The “flipped classroom” is a learner-centered approach that centers on delivering videos, podcasts or slide-based material to learners prior to a lecture or class session. The class session is then dedicated to discussion, analysis, and problem-solving activities. The aim of this study was to investigate whether the flipped classroom could be adapted to medical (ophthalmology) students learning about ocular trauma and to assess the impact of the flipped classroom on those students’ performance and attitudes.

Methods: Questionnaires (using a 4-point scale) were distributed to 93 fifth-year medical students at Sun Yat-sen University, and the data showed that the majority of students preferred the flipped classroom approach to the traditional lecture method.

Results: The results of pre- and post-test scores were 14.35 ± 3.404 and 20.37 ± 4.356 , which showed a significant improvement in students’ performance after the flipped classroom was introduced ($P < 0.05$).

Conclusions: Student response to the flipped classroom strategy was largely positive, indicating that the strategy received a high level of approval in an ophthalmology clerkship course taken by medical students in China.

Keywords: Flipped classroom; ophthalmology; clinical clerkship; medical education; teaching

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Introduction

For centuries, didactic teaching sections have occupied a large proportion of the available teaching-learning time in medical courses. This form of teaching has relied heavily on professors disseminating information through lectures and students passively absorbing knowledge for a majority of the class period. The extensive use of traditional lectures limits students’ time to actively learn, synthesize, analyze, and develop critical thinking skills. Attempts to make the precious teaching-learning time more efficient and to

promote student involvement in active learning led to the evolution of the “flipped classroom” or “inverted classroom” approach (1). The term “flipped classroom,” which was introduced in 2007, has been rapidly gaining popularity in the educational research literature worldwide (2,3).

As its name suggests, the “flipped classroom” is an inverted model of teaching that often uses communication or instructional technologies such as videos, podcasts or slides to deliver lecture material outside the classroom, so that classroom time is spent on discussion, analysis, and problem-solving activities (4). The “flipped classroom”

has been demonstrated to enhance medical students' performance in areas such as didactic and clinical experiences (5), neuroanatomy (6,7), palliative care skills (8), nursing education (9,10), cardiovascular, respiratory, and renal physiology (11), etc. However, there are no reports on the "flipped classroom" experience in ophthalmology. As we know, ophthalmology is an independent discipline of medicine that must combine knowledge and practical skills by continually reinforcing information that has been learned. The "flipped classroom" uses various technologies and methods in the process of teaching that could help students to retain an impressive amount of what they have learned. Because "cramming education" has existed for decades in Chinese education, it remains unknown whether the "flipped classroom" is suitable for Chinese students and whether the "flipped classroom" has the same remarkable effect in ophthalmology as in other disciplines.

To assess the impact of the "flipped classroom" model on students' performance and attitudes on ophthalmology, 93 medical students were subjected to this teaching model. Because "ocular trauma" is a complicated disease that can relate to every structure of the eyeball, an understanding of ocular trauma contributes to understanding eyeball disease overall and enhances students' motivation to learn. Therefore, we chose the chapter about "ocular trauma" as the topic for our flipped classroom. Evaluation questionnaires and pre- and post-test scores were collected to analyze this teaching model's effect and its acceptance among interning medical students in the year 2010.

Methods

The medical students chosen to evaluate the flipped classroom model are in the fifth year of an 8-year program at Sun Yat-sen University, located in Guangzhou, China. The students receive two years of premedical education and then follow a medical course that includes six years of basic medical, clinical medical, clerkship, and research training in medical school. The program is similar to medical education in many Western countries. We conducted the study among fifth-year students of ocular trauma and used the flipped classroom approach. Ninety-three students—50 males and 43 females between 22-28 years of age—participated in the study module. The teachers who were selected to participate all have a wealth of clinical and teaching experience. Before the flipped classroom experiment, we collected the following information from university records: the final grade for all curricula, which are provided

as a standard numerical grade (SNG) on a scale from 0 to 100, including the following subjects: Obstetrics and Gynecology, Pediatrics, Psychiatry, Neurology, Emergency Medicine, Disaster Medicine, Otolaryngology Head and Neck Surgery, Anesthetics, Dermatovenereology, Internal Medicine, Surgery, and Ophthalmology.

All of the students were randomly divided into four sections, each of which studied at Zhongshan Ophthalmic Center, Sun Yat-sen University, for one week. Each section was randomly divided into six groups. Three days before the flipped classroom sessions, the students were directed to review the subject of ocular trauma. One test consisting of three cases was completed by students in 20 minutes one day before the flipped classroom sessions. These three cases focus on penetrating injuries, contusions of the eyeball and chemical burns. Two or three questions were appended to each case scenario. An example of one such case scenario is as follows:

A 40-year-old man complains of impaired vision after his left eye was splashed by iron scraps 2 hours ago.

Question 1: What do you think is the most suitable check for him to perform? (no more than 5 items)

Question 2: What do you think is the most likely damage to this patient's eye? (no more than 5 items)

Question 3: What do you think is the most suitable treatment for this patient? (short answer)

Before the class, teaching assistants sent a PowerPoint presentation of ocular trauma, which had been converted into a portable document file (PDF), to all of the students. The students were asked to study the knowledge of ocular trauma in groups using the PDF file, textbooks, articles, e-publications or any other reference. Fifty-six questions were highlighted in the PDF to facilitate understanding of the key points of ocular trauma, such as "Why can blunt trauma produce a rise in intraocular pressure?", "Which tissues do you think were injured?" and so on. Each group of students was asked to prepare a simple presentation (no more than two PowerPoint slides) that listed what they had learned and what questions they wanted to ask.

At the flipped classroom session, when one group of students had finished its presentation, students in other groups were asked to answer the questions shown in the slides after a brief discussion. The instructor primarily acted as a guide to analyze the problems that the students could not solve. Students were encouraged to ask questions and offer comments throughout the class period. At the

conclusion of the session, a post-test was administered immediately to obtain feedback.

To investigate student satisfaction for each section of the flipped classroom and for the flipped classroom overall, students were asked to respond to 5 statements in each section of the questionnaire, which was graded on a 4-point scale to learn the students' satisfaction ratings. A score of 1 indicated strongly disagree; 2 indicated disagree; 3 indicated agree; and 4 indicated strongly agree. Both the number and percentage of students responding to each item were evaluated. The mean rating for each item was calculated. Students' suggestions and remarks were also recorded.

Statistical analyses

The pre- and post-test scores obtained by each student were calculated and a paired *t*-test was performed to determine the statistical significance of the difference. The correlation between the score obtained on the post-test and on the final exam in the Ophthalmology course was calculated using Spearman's correlation coefficient. In addition, the students' scores on the other summative exam were compared with scores obtained in the pre- and post-tests. Students' satisfaction ratings for each item were also calculated. $P < 0.05$ was considered statistically significant for all of the statistical tests.

Results

Student satisfaction

Fifty-seven of the 93 students responded to the questionnaires. From August to September 2015, 93 fifth-year medical students rotated through the ophthalmology clerkship. All of these students viewed the Ocular Trauma PowerPoint prior to the flipped classroom session and finished the presentation and case discussion. Fifty-seven students finished the evaluation questionnaire. Student satisfaction with this teaching method was high for both components. There were similarly high satisfaction responses in the general lecture assessment survey following the implementation of the flipped classroom. The responses to each statement are summarized in *Table 1*. As the data show, a large majority of the students preferred the flipped classroom approach to the traditional lecture method. Ninety-one percent of the students felt that the flipped classroom was useful for their preparation of the clerkship exam, 81.4% felt that this approach was positive and 89.8%

were willing to recommend this method to others. Ninety-three percent of the students also felt that this session helped them obtain a higher level of knowledge, and this method provided them with an incentive to actively engage with the subject before the class. A large number of students suggested that more flipped classroom sessions should be organized in the future. The mean rating for each category ranged between 3.14 and 3.91, indicating that the students were satisfied with this flipped classroom model.

Comments

Answers to open-ended questions were also collected: *What do you think about flipped classroom session? Do you have any suggestions or comments?* Most of the students responded to these questions, and the answers were shown in *Table 2* (duplicative suggestions were not listed). There were many positive student comments and suggestions about the pre-class PowerPoint and the classroom presentation and discussion. Some of the students suggested that giving different assignments to different groups would promote greater interest and enthusiasm. Some students complained about having too little time to study and prepare for the flipped classroom session, and others requested an explanation of the slides before being required to complete the work assignment.

Test scores

All 93 of the students completed examinations on the subject of ocular trauma both before and after the flipped classroom. There was a significant improvement in students' performance on the ocular trauma subject examination after the flipped classroom. The data were summarized in *Table 3*. The mean \pm SD of pre- and post-test scores were 14.35 ± 3.404 and 20.37 ± 4.356 , respectively. The paired T-test showed significant differences ($P < 0.05$) between the pre- and post-test scores. There was no difference ($P > 0.05$) among the four batches. The students showed a 42% improvement on the ocular trauma exam.

Gender differences

Gender difference in the test performance of flipped classroom students was analyzed. The results showed no significant difference in the test performance of male versus female flipped classroom students. Just as the data showed in *Table 4*, the P values at pre- and post-test are 0.807 and

Table 1 The questionnaire distributed to the students with their response to the flipped classroom model

Question	Responses (n=57)				Total	Mean rating
	1	2	3	4		
This activity is useful for preparing for the clerkship exam	1.7 [1]	6.8 [4]	47.5 [28]	44.1 [26]	3.34±0.685	3.46
I support expanding the use of this activity in the future	0	18.6 [11]	39.0 [23]	42.4 [25]	3.24±0.751	3.35
This activity was preferable to the traditional lecture format	0	32.2 [19]	40.7 [24]	27.1 [16]	2.95±0.775	3.05
I was satisfied with this activity	0	10.2 [6]	37.3 [22]	52.5 [31]	3.42±0.675	3.54
Overall I would rate this activity as positive	0	6.8 [4]	40.7 [24]	52.5 [31]	3.46±0.625	3.58
The information presented during the session was relevant to my education	0	8.5 [5]	39.0 [23]	52.5 [31]	3.44±0.650	3.56
The session was well organized	0	0	42.4 [25]	57.6 [34]	3.58±0.498	3.70
The presenter encouraged and provided opportunities for discussion	0	1.7 [1]	18.6 [11]	79.7 [47]	3.78±0.457	3.91
The presenter responded well to questions asked by the audience	0	0	27.1 [16]	72.9 [43]	3.73±0.448	3.85
The session helps me obtain a higher level of knowledge	1.7 [1]	5.1 [3]	45.8 [27]	47.5 [28]	3.39±0.670	3.50
The flipped classroom challenged me to give my best effort	0	5.1 [3]	47.5 [28]	47.5 [28]	3.42±0.593	3.54
The flipped classroom is an effective, motivating learning process	1.7 [1]	8.5 [5]	40.7 [24]	49.2 [29]	3.37±0.717	3.49
The presenter helped a lot throughout the session	0	13.6 [8]	55.9 [33]	30.5 [18]	3.17±0.647	3.28
I frequently study with colleagues	1.7 [1]	10.3 [6]	48.3 [28]	39.7 [23]	3.26±0.715	3.31
This activity was preferable to the traditional lecture format	1.7 [1]	27.1 [16]	37.3 [22]	33.9 [20]	3.03±0.830	3.14
The flipped classroom promoted effective cooperative learning	5.1 [3]	22.0 [13]	37.3 [22]	35.6 [21]	3.03±0.890	3.14
The flipped classroom promoted reading of the student textbook	0	19.0 [11]	37.9 [22]	43.1 [25]	3.24±0.757	3.30

The survey questions used a four-point scale (1, strongly disagree; 2, disagree; 3, agree; 4, strongly agree). Data reported as means ± standard deviations.

0.204, respectively.

Correlation

In addition, there is no correlation between students' improvement on this test and their level of learning, which

was evaluated by their entrance exam scores, scores of other clinical subjects and their scores on an ophthalmology theory test. As *Figure 1* shows, there was a weak positive correlation between difference (d) and students' scores on the ophthalmology theory test and between d and average grades in the students' other classes. No correlation

Table 2 Common feedback statements related to the flipped classroom approach

More organization is needed to master better learning methods in the flipped classroom

It's awesome. I learned more in this class

The questions in the courseware greatly helped me to think more deeply

Very good! I highly recommend more flipped classrooms in the next season. I suggest preparing two subjects for the teams because there is too much overlap if all six groups do the same subject

The content of the PowerPoint should be more abundant

Preparation time is limited

There are too many overlaps between groups. The topic assignments may have adverse impact on divergent thinking

The flipped classroom could improve interest in autonomous learning. We need more of the flipped classroom!

It would be better if the teacher could explain the content of the PowerPoint at the beginning

This model emphasizes training one to think while discounting knowledge itself

Discussion about clinical cases might be more interesting. Ocular trauma covers a lot of ground, which makes the topic somewhat vague

Assigning different tasks to different teams will help us to learn more deeply

The flipped classroom is beneficial to help us combine theory and clinical practice, but it is more applicable to those students who have finished their theoretical education; those students will have a better experience

I love this teaching model, it is great if you can have more classes like this so that we can have more time to discuss about problems that we are interested in

Most of the questions in the PowerPoint are about clinical trial, but all of us still lack experience in that area. It would be better to conduct the flipped classroom at the end of our ophthalmology clerkships

Table 3 Analysis of pre- and post-test scores when the flipped classroom method is used

Ophthalmology quartiles	n	Before	After	d	t	P value
Total	93	14.35±3.404	20.37±4.356	6.02±4.749	-37.822	0.000*
Round 1	20	15.00±3.244	19.75±4.908	4.75±5.830	-17.919	0.000*
Round 2	27	13.65±3.863	20.78±4.560	7.13±4.811	-15.971	0.000*
Round 3	19	14.37±4.219	20.79±5.181	5.56±3.886	-12.778	0.000*
Round 4	27	14.56±2.276	20.11±3.080	6.02±4.749	-24.607	0.000*

Data reported as means ± standard deviations. *, P<0.05 considered significant.

Table 4 Gender difference analysis in test performance of flipped classroom students

Test	Mean score ± standard deviation		P
	Male [50]	Female [43]	
Before	14.43±3.662	14.26±3.117	0.807
After	20.90±4.559	19.74±4.071	0.204
D	6.47±4.874	5.49±4.600	0.234

Data reported as means ± standard deviations.

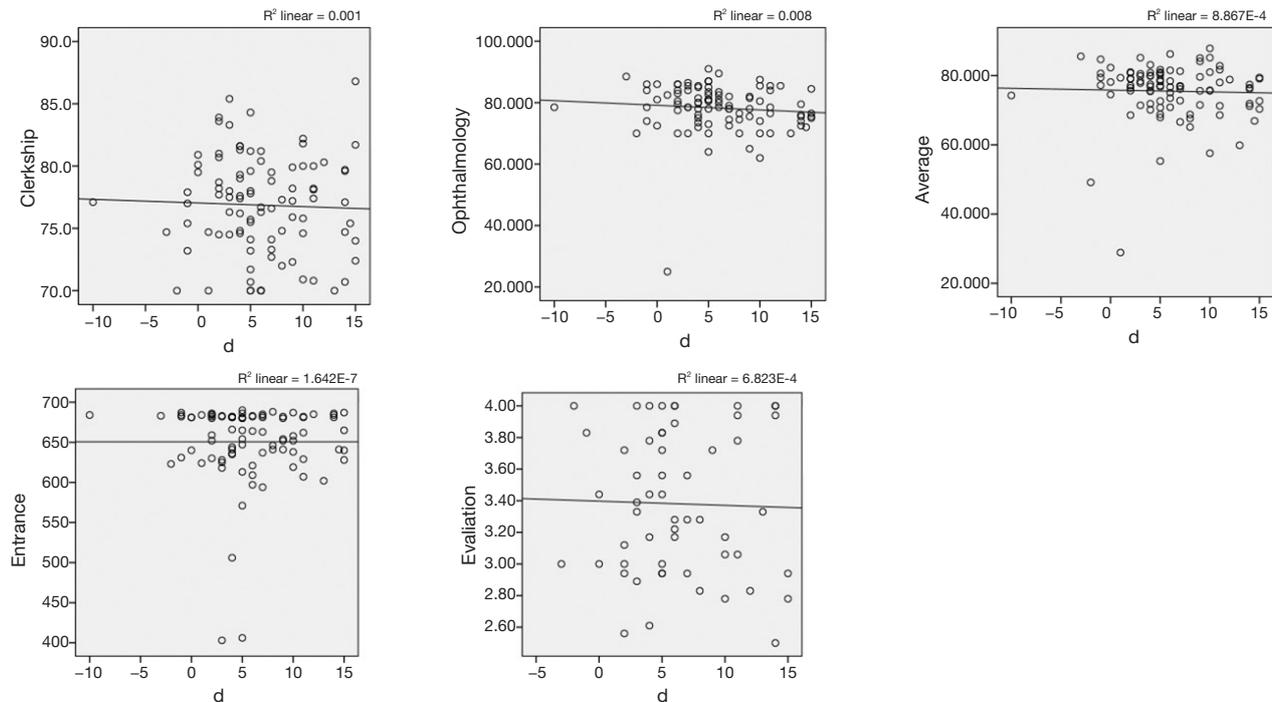


Figure 1 Correlation analyses of students' performance, evaluation of the flipped classroom pedagogy, students' entrance-exam scores and students' scores in other clinical courses.

was noted between *d* and scores on the ophthalmology clerkship, scores on the college entrance exam and their evaluation of the teaching approach.

Discussion

The International Council of Ophthalmology (ICO) has recognized the importance of ophthalmology education in improving eye care globally and has identified ophthalmic education as one of the cornerstones of its strategic plan to preserve and restore vision worldwide (12). For decades, we have devoted ourselves to improving the quality of ophthalmology education. Clinical clerkship courses are crucial parts of medical education in which students acquire real experience and apply theory to practice (13). There are several reasons that the “flipped classroom” may be suitable for the clinical ophthalmology clerkship. First, ophthalmology is a discipline based on primary medical knowledge and once that knowledge has been gained, students have the ability (to some extent) to engage in self-directed learning. Moreover, as an independent discipline, many reliable learning resources for ophthalmology make it feasible for students to practice self-learning. In addition, the efficiency of eye care in the modern practice

of ophthalmology depends on teamwork (12). Working in a group in the flipped classroom process promotes team cooperation skills among students. Multiple forms of teaching, including ophthalmologic examination training, the flipped classroom, team-based learning (TBL) and scenario simulations were used in the ophthalmology clerkship course. This study centered on the ocular trauma unit completed in the ophthalmology clerkship course at the Zhongshan Ophthalmic Center of Sun Yat-sen University.

Our successful implementation of the flipped classroom curriculum for ophthalmology topics successfully proves that the flipped classroom is an effective pedagogy: student approval increases with this novel teaching model, as does their learning efficiency. First, our evaluation showed that a high student-satisfaction rate. Moreover, our results demonstrated that knowledge of ophthalmology was significantly improved in students after the flipped classroom. Moreover, we found that there was no difference in flipped-classroom test performance between male and female students. In addition, no correlation between students' improvement on the test and their level of learning was found.

As we know, the concept of the “flipped classroom” was proposed by Jonathan Bergmann and Aaron Sams, two

high-school chemistry teachers from Colorado (United States), in 2012. They had begun flipping the teaching and learning scenarios in 2007. The flipped classroom model (also called an inverted classroom) has been rapidly gaining popularity in undergraduate education and graduate education around the world (2,3). Although students who have been subject to the flipped classroom approach have been evaluated in a wide range of disciplines, including pharmacy (3), economics (14), engineering (15), physics (16), and so on, there has been no flipped classroom study in the field of ophthalmology reported until now. Therefore, our study evaluated the effectiveness and the degrees of approval for the flipped classroom in an ophthalmology clerkship course.

The key to educational success is for students to have their own enthusiasm and learning activities. Several advantages of the flipped classroom that promote enthusiasm and learning activities contribute to the high satisfaction rate of the students in our study. First, the flipped classroom increases flexibility in learning: because students were able to work at their own pace before class, they could review the lecture files as many times as needed to better understand the key concepts. Additionally, students were encouraged to work in groups to further their understanding by critically thinking about the subject and actively discussing it in a collaborative classroom setting. Furthermore, after the questions list in the presentation that was provided by each group during class was discussed by the other groups, the instructor analyzed the problems that the students could not solve. In this manner, the flipped classroom made learning more manageable for students by resolving difficult questions and complex concepts and making them more understandable and accessible. Therefore, as stated in previous studies, the flipped classroom is an effective teaching method that promotes student thinking both inside and outside the classroom (17). Evidence also indicates that engaging students in active learning enhances their learning outcomes, higher-order thinking, problem solving, and critical analysis and improves their motivation and learning attitudes (18). All of these factors contribute to the higher ophthalmology examination scores gained after the flipped classroom.

The most common student complaint (“strongly disagree”) in our study related to the proposal that the “Flipped classroom promoted effective cooperative learning,” which drew a “strongly disagree” rating of 5.1%. There are several well-reasoned explanations for this finding. For the group presentations, some students

did not do their best in group work because the final mark in this section was dependent on the team’s showing. Some students even suggested placing students who were unwilling to contribute to the team into the same group to increase their accountability. In other cases, students conveyed that they did not enjoy the group presentations because giving a lecture on the platform was considered an “uneasy” or “frightening” experience. Another common student complaint was the “overwhelming” amount of pre-class preparation time. Because of time limitations, there is only one week for the ophthalmology clerkship course in our hospital, and the flipped classroom demands large amounts of pre-class preparation time. Therefore, students complained that “Preparation time is limited.”

There might be several reasons for the lack of a difference in the flipped-classroom test performance between male and female students. The in-class flipped classroom section involved group presentations and the final mark was a collective (group) mark, every student in a group received the same evaluation. Moreover, female students make more effort to learn knowledge, whereas male students have a higher ability to apply knowledge. Consequently, there was no significant difference in the final test scores in our study.

Another interesting result is that although different students earned different scores on the National College Entrance Examination, and their scores in other clinical subjects and ophthalmology theory tests varied (which means that they have different abilities to learn), there is no correlation between students’ test improvement after the flipped classroom and their level of learning. This interesting result also proves that the flipped classroom is an effective pedagogy to enhance every student’s learning activity and to promote most students’ ability to solve problems.

Limitations

Several limitations of this study must be addressed. First, no control groups were used during the period under investigation to compare the effectiveness of the flipped classroom and that of traditional methods. Because “ocular trauma” is a complicated disease and the teaching effect is usually unsatisfactory, we make a vertical comparison before and after the process of the flipped classroom. Second, a relatively small number of students enrolled in this study. Because an elite medical education is one of the characteristics of our university, no more than 100 students are enrolled each year. This is also one reason

that we could not compare the flipped classroom approach with a control group taught using didactic methods. Finally, because we do not have long-term follow-up results (e.g., repetition of the test after a semester), we cannot determine how much knowledge was retained by the participants.

Conclusions

Overall, the format of the flipped classroom increased students' abilities in the areas of obtaining knowledge, critical thinking, problem solving, and interacting with and learning from other students. Because the flipped classroom represents a new teaching approach, the high level of student satisfaction was gained in implementing the flipped classroom curriculum. This is the first study to prove that the flipped classroom is an effective teaching approach that obtains most students' approval in an ophthalmology clerkship course in China.

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