

Evaluating the Effectiveness of the Flipped Classroom Model in Anatomy Education: A Quasi-experimental Study

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ABSTRACT

Introduction: The Flipped Classroom (FC) is a collaboration between students and faculty members in which different strategies are adopted to enhance the teaching-learning process. In this model, students are required to prepare prior to the scheduled class using handouts, outlines and notes provided by the instructor, which helps increase their productivity during the lecture. Every approach should be tested and applied based on personal experience and knowledge. Therefore, this teaching method, commonly known as the inverted classroom, can be considered one of the best resources for student engagements and can help create an ideal, interactive classroom environment.

Aim: To evaluate the effectiveness of the FC approach compared to traditional lectures and to assess perceptions of the FC method in learning anatomy.

Materials and Methods: A quasi-experimental study was conducted with Bachelor of Medicine and Bachelor of Surgery (MBBS) Phase I students at the Department of Anatomy, Chirayu Medical College and Hospital, Bhopal, Madhya Pradesh, India, from July 2023 to December 2023. A total of 150 students were divided into two groups: Group-A (odd roll numbers) attended traditional lectures on the thyroid gland, while Group-B (even

roll numbers) participated in a FC approach. Pretests and post-tests, consisting of multiple-choice questions, were administered to both groups. Students' perceptions were assessed using a prevalidated questionnaire based on a five-point Likert scale for both methodologies. Student's t-test was employed to compare the pretest and post-test results, with $p < 0.05$ considered statistically significant.

Results: The mean age of students in Group-A was 20 ± 1.67 years, while the mean age of students in Group-B was 20 ± 1.42 years. Significant improvements in knowledge scores were observed in both Group-A ($p = 0.005$) and Group-B ($p < 0.001$) following the lecture. However, the increase in post test scores was significantly higher in Group-B compared to Group-A ($p = 0.0013$). A total of 100% of the students in Group-B preferred the FC format over the traditional lecture. Additionally, all students in Group-B agreed that more topics should be covered using the FC approach, as it increased their confidence in performing and would improve their assessment outcomes.

Conclusion: The FC method has proven to be an effective teaching and learning approach in anatomy. The majority of students felt that the FC technique improved their problem-solving skills and this approach has been beneficial in all aspects.

Keywords: Competency-based medical education, Instructional approach, Learning strategy, Self-regulated learning

INTRODUCTION

Medical teaching forms the foundation of the entire field. Developments for effective teaching are the need of the hour. Therefore, a methodology to address the needs of students by increasing their involvement in the entire process is required. This has led to the evolution of the FC, commonly referred to as the inverted classroom approach [1]. The FC model is a pedagogical practice that involves students independently acquiring knowledge before in-person class sessions, during which they engage in active discussions and problem-solving [2].

Every journey is an amalgamation of various components, each required at a specific stage. Various methods to implement the FC model include quizzes, e-content, case-based learning, problem-based learning and reading assignments [2]. The journey of the FC begins with the constant efforts put in by students, who study using handouts provided by the faculty in the form of Powerpoint presentations (PPT), Portable Document Format (PDF) and videos prior to the delivery of the lecture. The primary knowledge gained by the students results in a brainstorming problem-solving session led by the respective faculty. Initially, students are divided into subgroups, where they can raise questions and engage in debates to develop their understanding and later gain clarity from the faculty [3]. When the same content is read beforehand by the students,

it provides them with a basic understanding of the topic. This technique not only adapts to the difficulty level of the material but also allows students to learn at their own pace. Rapid-fire rounds and interactive discussions not only help to arouse students' interest but also increase their inquisitiveness. Faculty, who were once commonly referred to as the "sage on the stage," have now taken on the role of "guide by the side" [4].

The core concept can be easily learned using the outlines and handouts provided by the faculty or instructor. These materials will serve as aids for revision purposes as well. Additionally, experimentation and critical thinking exercises are practiced in the classroom. The level of understanding is later assessed through time-bound assignments in various formats, such as multiple-choice tests or short answer questions [5]. The numerous advantages of this technique are extensive. Firstly, it provides flexibility in terms of time; information can be accessed from anywhere at any time. Secondly, it allows for independent pacing in learning. Thirdly, it prepares students for upcoming challenges by sharpening their higher-order thinking skills [6].

On the other hand, the second step involves using offline classes to provide hands-on activities with desired experimentation. This approach helps keep students engaged and enhances their knowledge through involvement in time-bound homework and class meetings [7].

It is essential to adopt such techniques in common practice to bridge the gap between students and teachers, which is crucial for focusing on improved results. However, in medical education, most institutions continue to follow traditional methods for delivering lectures. The application of any new methodology is vital and it requires familiarity with the method. This necessitates joint efforts from both teachers and lecturers [8].

Thus, the present study was conducted to assess students' perceptions regarding the FC versus traditional lectures as methods of teaching anatomy. Hence, the aim of the study was to evaluate the effectiveness of the FC compared to traditional lectures and to assess students' perceptions regarding the FC.

MATERIALS AND METHODS

The present quasi-experimental study was conducted in the Department of Anatomy at Chirayu Medical College and Hospital in Bhopal, Madhya Pradesh, India, from July 2023 to December 2023. Approval for the study was obtained from the Institutional Ethics Committee (CMCH/EC/2023/76, dated July 10, 2023). Informed consent was obtained from each participant.

Inclusion criteria: Students aged 18-25 years, enrolled in the MBBS Phase I of the 2022-2023 batch, who were present on the day of the session and willing to participate were included in the study.

Exclusion criteria: Students who were not willing to enroll in the study were excluded.

Sample size: The sample size was not calculated statistically, as all 150 first-year students were included. They were divided into groups based on their odd and even roll numbers five days prior to the intervention: Group-A (odd roll numbers) and Group-B (even roll numbers). Group-A attended a traditional lecture on the thyroid gland, while Group-B participated in a FC.

Study Procedure

The students in Group-B were sensitised by being informed about the desired topic, the thyroid gland, five days before the FC session. Resource materials were provided prior to the class, which included Microsoft Powerpoint handouts, outlines, self-made videos and PDFs. The content was standardised prior to the study by a faculty member from the same department. Furthermore, all students were advised to review the provided study material again before the session. They were also encouraged to create mind maps, short notes and formulate questions related to the assessment prior to the next FC session.

On the day of the intervention, only 64 students were present and enrolled in Group-A, while approximately 74 students participated in Group-B. Pretests and post-tests were conducted for both groups. A total of 10 multiple-choice questions based on the core competencies of the thyroid gland were administered. The same questions were used for both the pretest and post-test. One mark was awarded for each correct answer, while no marks were given for incorrect answers. The questions were based on the content covered during the session. The post-test was conducted immediately after the traditional lecture. The time allocated for the pretest during the traditional lecture was 10 minutes, while one hour was given for the lecture itself; the post-test and feedback each lasted for 10 minutes.

Group-B underwent the FC technique, during which subgroups were formed (15 students each in Groups 1 to 4 and Group 5 had only 14 students) on the same topic for one hour [Table/Fig-1]. A pretest was administered before the start of the session on the day of the intervention. The session was facilitated by the instructions provided by the teacher, along with a detailed explanation of the study's steps. Subtopics related to the thyroid gland were prepared by the faculty and each group was assigned their respective subtopics by the group leaders. The group leaders distributed

the topics among the group members and group dynamics were followed, which encouraged thorough discussion on the topic to promote active participation from each student. The facilitators guided the students and addressed their questions. Pre- and post-tests were conducted for Group-B in the same format on the same day, with the post-test administered immediately after the session. In the FC format, the pretest lasted for 10 minutes, while the FC technique was applied for 30 minutes, followed by a presentation lasting 45 minutes. At the end of the session, the post-test and feedback were collected, each lasting for 10 minutes.

Thyroid gland (traditional lecture) for Group-A	Thyroid gland (FC) for Group-B, five subgroups
1. Introduction 2. Location 3. Shape and extent 4. Relations 5. Structure 6. Arterial supply 7. Venous drainage 8. Nerve supply 9. Lymphatic drainage 10. Clinical aspect	Group-1: Introduction, Location, Shape and Extent Group-2: Relations, Structure Group-3: Arterial Supply, Venous drainage, Nerve supply Group-4: Lymphatic drainage Group-5: Clinical aspect

[Table/Fig-1]: Topics covered during traditional teaching and Flipped Classroom (FC).

The assessment of student perception was conducted using a five-point Likert scale, ranging from 1 to 5 (strongly disagree to strongly agree). The questions were prepared by the author and included ten feedback items based on the methodology of the FC and students' experiences. Validation was carried out by a faculty member from the community medicine department. The questionnaire was distributed via Google Forms by the author and the responses were evaluated.

STATISTICAL ANALYSIS

Epi Info 7.1 was used for the analysis. Data were entered in a spreadsheet and expressed as mean $\pm$ SD after comparing the data, students' perceptions were assessed using a five-point Likert scale, with percentage agreement defined as the sum of the responses "strongly agree" and "agree." A p-value of less than 0.05 was considered statistically significant and the p-value was determined using a t-test. Students' responses to each question were expressed as overall median, mean and mode.

RESULTS

The mean age of students in Group-A was 20 $\pm$ 1.67 years, while the mean age of students in Group-B was 20 $\pm$ 1.42 years. The majority of students in Group-A were female 33 (51.56%), whereas the majority in Group-B were male 38 (59.37%). In Group-A, the minimum score in the pretest was one and the maximum score was six out of 10, while the minimum score in the post-test was two and the maximum score was seven out of 10. In contrast, in the FC method, the minimum score on the pretest was two and the maximum score was seven out of 10, with a minimum score of five and a maximum score of nine out of 10 on the post-test. According to [Table/Fig-2], significant improvements in knowledge scores were observed in both Group-A (p=0.005) and Group-B (p<0.001) following the lecture.

In intergroup comparisons, a significant difference was observed between the groups both at pretest and post-test, with Group-B performing better in both instances (p=0.001) [Table/Fig-3]. However, the increase in knowledge scores was significantly higher in Group-B compared to Group-A (p=0.0013).

The students' responses to the feedback questionnaire regarding traditional teaching methods is presented in [Table/Fig-4]. A total of 42 students (65.62%) agreed that the appropriate use of visual aids enhanced their understanding of the topic and helped them retain the concepts. The instructor's knowledge and expertise were evident and 32 participants (50%) felt that the opportunities

Group	Test	Number of students, n	Mean±SD	Difference of pretest of both methodology	Difference of post-test of both methodology	Difference of post and pretest score	p-value
Group-A Traditional lecture	Pretest	64	3.89±1.39	0.65	2.77	0.73	0.005*
	Post-test	64	4.62±1.44				
Group-B Flipped Classroom (FC)	Pretest	74	4.54±1.04			2.85	0.000*
	Post-test	74	7.39±1.18				

[Table/Fig-2]: Post-test scores of Group-A, traditional lecture and Group-B, Flipped Classroom (FC) in the form of mean, standard deviation and p-value.

*indicate significant, p-value <0.05

Test	Groups	Number of students 'n'	Mean±SD	p-value
Pretest	Group-A Traditional lecture	64	3.89±1.39	0.001*
	Group-B Flipped Classroom (FC)	74	4.54±1.04	
Post-test	Group-A Traditional lecture	64	4.62±1.44	0.001*
	Group-B Flipped Classroom (FC)	74	7.39±1.18	

[Table/Fig-3]: Intergroup comparison between two methodologies, traditional teaching and Flipped Classroom (FC) and their p-value.

*indicate significant, p-value <0.05

for student-teacher interaction were adequate. Nevertheless, 41 students (64.06%) expressed a preference for traditional lectures as their preferred learning method.

The students' responses to a feedback questionnaire regarding the FC approach is presented in [Table/Fig-5]. According to 69 participants (93.2%), the FC improved their problem-solving skills and this approach proved to be beneficial in all aspects. All 74 students (100%) preferred the FC over traditional lectures. Additionally, all students (100%) agreed that more topics should be covered using the FC model. Furthermore, all participants agreed that the FC increased their confidence in performing tasks and would enhance their assessment outcomes.

Questions	Strongly disagree n (%)	Disagree n (%)	Undecided/neutral n (%)	Agree n (%)	Strongly agree n (%)
Q-1: Complex anatomical concepts were explained effectively by the instructor using traditional lecture format.	2 (3.1%)	3 (4.6%)	22 (34.3%)	30 (46.8%)	7 (10.9%)
Q-2: The appropriate usage of visual aids enhanced my understanding of the topic and helped me retain the concept.	1 (1.5%)	1 (1.5%)	20 (31.2%)	33 (51.5%)	9 (14%)
Q-3: The pace of the instructor was suitable and helped me grasp the content well and take down effective notes for future reference.	4 (6.2%)	3 (4.6%)	27 (42.1%)	21 (32.8%)	9 (14%)
Q-4: The instructor's knowledge and expertise were evident and the opportunities given for student teacher interaction were adequate.	3 (4.6%)	5 (7.8%)	24 (37.5%)	24 (37.5%)	8 (12.5%)
Q-5: The instructor's delivery style (voice, tone, gestures) kept me engaged during the session.	3 (4.6%)	5 (7.8%)	27 (42.1%)	19 (29.6%)	10 (15.6%)
Q-6: The lecture slides were clear, concise effective and helpful.	5 (7.8%)	4 (6.2%)	19 (29.6%)	27 (42.1%)	9 (14%)
Q-7: Overall, I found the traditional lecture-based approach beneficial for learning Anatomy.	2 (3.1%)	5 (7.8%)	23 (35.9%)	22 (34.3%)	12 (18.7%)
Q-8: The traditional lecture-based approach in Anatomy provided a solid foundation for further studies.	2 (3.1%)	6 (9.3%)	20 (31.2%)	25 (39%)	11 (17%)
Q-9: The explanation and doubt solving process was appreciated.	1 (1.5%)	8 (12.5%)	25 (39%)	23 (35.9%)	7 (10.9%)
Q-10: I would prefer traditional lecture for learning.	4 (6.2%)	1 (1.5%)	18 (28.1%)	26 (40.6%)	15 (23.4%)

[Table/Fig-4]: Students response to feedback questionnaire about traditional teaching of thyroid gland, n=64 Group-A.

Questions	Strongly disagree n (%)	Disagree n (%)	Undecided/neutral n (%)	Agree n (%)	Strongly agree n (%)
Q-1: The pre-reading material provided more autonomy for students than to depend on the facilitator and thus reflected as an appreciable tool.	0 (0%)	0 (0%)	3 (4.05%)	42 (56.7%)	29 (39.1%)
Q-2: Flipped Classroom (FC) provoked interest in learning and engaged all by working in a group. This helped to grasp content well.	0 (0%)	0 (0%)	3 (4.05%)	40 (54%)	31 (41.8%)
Q-3: Flipped Classroom (FC) improved my problem-solving skills and this approach proved to be beneficial from all sides.	0 (0%)	0 (0%)	5 (6.7%)	26 (35.1%)	43 (58.1%)
Q-4: Flipped Classroom (FC) helped me sharpen my critical skills and taught me the importance of good communication skills.	0 (0%)	0 (0%)	0 (0%)	49 (66.2%)	25 (33.7%)
Q-5: The Flipped Classroom (FC) helped me in better application of the concept.	0 (0%)	0 (0%)	0 (0%)	31 (41.89%)	43 (58.1%)
Q-6: The learning process of Flipped Classroom (FC) kept me motivated during the entire session.	0 (0%)	0 (0%)	0 (0%)	44 (59.4%)	30 (40.5%)
Q-7: I would prefer Flipped Classroom (FC) over traditional lecture.	0 (0%)	0 (0%)	0 (0%)	30 (40.5%)	44 (59.4%)
Q-8: More topics should be covered in the Flipped Classroom (FC) mode.	0 (0%)	0 (0%)	0 (0%)	38 (51.3%)	36 (48.6%)
Q-9: Flipped Classroom (FC) will increase my confidence in answering in exams and will improve assessment.	0 (0%)	0 (0%)	0 (0%)	32 (43.2%)	42 (56.7%)
Q-10: FCR provides a learning environment and a session for discussion.	0 (0%)	0 (0%)	19 (25.6%)	2 (2.7%)	53 (71.6%)

[Table/Fig-5]: Students response to feedback questionnaire about Flipped Classroom (FC) of thyroid gland, n=74 Group-B.

DISCUSSION

In the present study, the increase in knowledge scores was significantly higher among students taught using the FC method compared to those taught through traditional teaching ($p=0.0013$). According to 93% of the participants, the FC improved their problem-solving skills and this approach proved to be beneficial in all aspects. All 100% of the students preferred the FC over traditional lectures. Furthermore, all students (100%) agreed that more topics should be covered using the FC method. Additionally, all participants agreed that the FC increased their confidence in performing tasks and would improve their assessment outcomes.

In a study by Veeramani R et al., the authors concluded that 86% of students felt that the FC approach was better at fulfilling the learning objectives than conventional didactic teaching. It was clearly evident that 92% of students felt that the pretest given to check their knowledge helped them acclimatise to the session effectively. Additionally, 87% of students agreed that the internet-based resources provided them with a better advantage [1]. In this study, 95.9% of students realised that the pre-reading material offered more autonomy to students, allowing them to depend less on the facilitator, which was reflected as an appreciable tool.

Bhavsar MH et al., concluded that there was a statistically significant difference (p -value <0.05) in post-test scores of both FC groups in both modules (FC Method: 14.77 ± 2.16 and 11.26 ± 1.76 vs Traditional Didactic Classroom (TDC) Method: 12.16 ± 2.05 and 10.03 ± 2.57). Overall, positive feedback was received for the FC method of teaching compared to the TDC method [2]. In the present study, 100% of students concluded that the FC helped them in better application of concepts and all students preferred the FC over traditional lectures.

According to a study conducted by Viveka S et al., the mean scores of the regular and FCs were 12.92 ± 3.13 and 13.41 ± 3.38 , respectively. The post-test scores improved in the FC when compared to regular classes [3]. Similarly, in the present study, the post-test scores of the FC showed more improvement compared to traditional lectures. In 2019, Dodiya D et al., concluded that there was a statistically significant improvement in post-test outcomes in FC methods when compared to traditional classroom methods. 67% of students agreed that learning was improved with the FC [4].

Arathi MS also concluded that both the FC and traditional lectures improved students' knowledge, although the increase was more significant in the case of the FC [5]. Komala HK found that 76.66% of students agreed that the FC was more engaging and interesting compared to the traditional class [6]. A similar finding was noted in the present study, where 95.9% of students agreed that the FC provoked interest in learning and kept them engaged by working in groups, which helped them grasp the content well.

In this study, 100% of participants agreed that the learning process in a FC kept them motivated throughout the entire session. Additionally, 74.3% agreed that the FC approach provided a better learning environment and enhanced interaction among them. Similarly, Sreegiri S et al., from Visakhapatnam in 2018 reported that 49.07% of students felt a boost in their self-motivation due to the FC technique. Furthermore, 63.79% of students indicated that less time was spent on traditional methods of learning, such as self-study. Additionally, 62.57% of students expressed that they enjoyed taking online tests and quizzes. The majority, 76.06% of students, perceived that the FC offered greater opportunities for communication with one another [7].

Studies by O'Malley CB, Pandey P et al., Patkar KU et al., and Junhua X concluded that the FC method was more effective than traditional lectures [8-11]. The FC improved my problem-solving skills and this approach proved to be beneficial. Sourg HAA et al., concluded that more than 80% of the students were happy and satisfied with the technique. In contrast, 90% of students found motivation and vigour in learning through this method [12]. In the present study, 95.9% of students agreed that the FC provoked interest in learning and kept them engaged. Thus, this study adds to the evidence that the FC method can be implemented as an effective teaching strategy.

Limitation(s)

There is a lack of evidence regarding knowledge retention and the assessment of procedural skills and higher-order thinking in the FC model. The management of resources has proven to be a time-consuming process and organising these resources has presented a significant time constraint. Conducting sessions in this format also requires a considerable amount of time. It is difficult to determine whether the FC approach is more applicable and beneficial for undergraduate students or if it offers greater advantages for postgraduate students, as only one topic was covered.

CONCLUSION(S)

The FC method improved knowledge scores compared to traditional lectures. All participants agreed that the FC approach helped them better apply concepts, kept them motivated throughout the entire session and increased their confidence in answering exam questions. Further research on the present study will help reflect on the numerous benefits it offers. As a result, this method can be adopted in medical education across all institutions with the aim of delivering factual content while enhancing overall efficiency.

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