Effectiveness of Flipped Classroom and Team-Based Learning in Teaching Biochemistry to Medical Students

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ABSTRACT

Objective: To compare the effectiveness of Team-based learning and flipped classrooms in terms of test scores in undergraduate medical education.

Study Design: Quasi-experimental study.

Place and Duration of Study: Federal Medical College, Islamabad Pakistan, from Mar to Jun 2020.

Methodology: A total of 100 first-year MBBS students were randomly equally allocated to either team-based learning or flipped classroom for biochemistry class. In the former technique, students were assigned a topic from the textbook as pre-reading material. In contrast, in the latter technique, they were given an audio-based power-point lecture before class. Then, students were asked to review the material and prepare at least three questions to ask during class in the flipped classroom while they followed a modified team-based learning class. In the first session, there were (n=43) and (n=39) students in the Team-based Learning and Flipped Classroom group, whereas in the second session, 40 students each attended class. However, in the third and fourth sessions, attendance was 100.0%. Each session was given a pre and post-test based on 20 Multiple Choice Questions.

Results: Females were in the majority (57%), and most students (72%) were 17 years of age. Team-based learning scored better than Flipped Classroom in each session. For example, in session 1, the mean scores were 67.0 ± 10.4 in Team-Based Learning and 48.3 ± 8.4 in Flipped Classroom group (*p*-value <0.001). The difference in marks obtained continued in sessions 2, 3 and 4.

Conclusion: Team-Based Learning is more effective than Flipped classrooms in teaching biochemistry to medical students.

Keywords: Flipped classroom, Learning methods, Medical education, Team-based learning, Test scores.

INTRODUCTION

Medical students often face trouble cramming the complex knowledge basis and recognizing the relevance of biochemistry for their later professional work. This can lead to lower motivation to learn biochemistry contents and dissatisfaction in the course among students.[1] Adapting active learning strategies instead of didactic lecturing pedagogy seems to be an effective solution.[2]

Medical education has revolutionized by introducing concepts such as hybrid learning models and distant learning. In addition, several new teaching methods have been tested, and results show significantly enhanced performance.

Several studies have reported the use of alternative teaching techniques in various disciplines.[3] For example, Nishigawa *et al*, from the School of Dentistry, Tokushima University Japan, reported better scores achievement in the TBL group than the FC. However,

not statistically different.[1]

FC is defined as an educational technique where baseline information regarding any topic discussed in the class is acquired independently before the actual classroom. The self-learning phase allows free time in the on-site phase, which can be used to teach competency-based learning objectives.[4] The various components of an FC session can also be utilized as a heterogeneous "blended learning" technique and supplemented with foundational ideas.[5]

In 2001 Baylor College of Medicine introduced team-based learning, which has a short track record than PBL technique.[6] Designed as an active learning strategy, TBL is though instructorled but is learner-centred. It nurtures individual and team accountability in small groups who work and respond in combination to queries.[7]

In TBL, a three-phase sequence is employed; i) selected topic assigned in advance for preparation by the learners, ii) an assurance of readiness through individual and group activity of learning, which may demonstrate via readiness assurance tests (RATs), and

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iii) applied, faculty designed and analyzed concepts of the course in problem-solving exercises.[8]

The advocates of FC methodology vow that classroom time is spent engaging in activities like problem-solving or debates.[5] Since team-based learning is also a flipped classroom type, its application is a contemporary alternative to traditional teaching. However, evidence is scarce on the quantitative and qualitative comparison of two active learning strategies, i.e. Flipped classroom (FC) and team-based learning (TBL), and their effects on teaching medical Biochemistry in a genuine educational context.[9,10]

The objective of this study was to compare the effectiveness of teaching biochemistry through the flipped classroom with team-based learning in undergraduate medical students based on their MCQ scores.

METHODOLOGY

This quasi-experimental study was conducted at Federal Medical College, Shaheed Zulfiqar Ali Bhutto Medical University, Islamabad Pakistan. The data collection was done in 4 months, from March 2020 to June 2020. The Ethical Review Committee approved the study of Riphah International University, Rawalpindi (ltr no. Riphah\IIMC\IRC\20\032 dated Feb 19, 2020).

Inclusion Criteria: The study population comprised of medical students of 1st-year MBBS who were accessible as they attended the classes.

Exclusion Criteria: Non-consenting or absent students were excluded from the study.

Though the majority of the students attended the class, still there were a few who were absent due to various reasons. They were taken as non-responders to the study. Students were taught using the two interventions, i.e. TBL and FC. Topic 'Enzymes' of biochemistry was taught in four sessions. In each session, students were given a test based on 20 MCQs before and after each session.

The sample size was calculated using Open Epi version 3.0. With a two-sided alpha of 1% and study power of 80.0% with a prevalence of indicator in the exposed group at 35.0% and non-exposed group at 5.0% with 1:1 in both arms, the sample was 47 in each study arm which was rounded off to 50 subjects in each group.[11] The total study sample size was estimated to be 100 undergraduate medical students of MBBS first-year taking biochemistry classes. Therefore, the whole first-year MBBS class was the sample of the study. A stratified random sampling technique was applied. The students were stratified based on their pre-medical exam scores as high, medium and low achievers ranging between 90 to 96. The allocation of students to either teaching technique was done by lottery in the three stratifications.

Students in both FC and TBL groups were then given study material, i.e. recorded audiovisual lectures in FC and notes/material shared on their "WhatsApp group" in case of TBL. Furthermore, in the pre and post-test, students were given 20 MCQs to collect data before and after each session.

It is pertinent to mention here that the methodology was modified in the wake of the pandemic hitting and closure of educational institutions. The class format was re-organized on the zoom app for the interactive part of the study. The teaching material was uploaded in Google classroom, which was the adopted mode of instruction in Federal Medical and Dental College during the pandemic. The structured interactive phase of flipped classroom was held on live zoom sessions, starting with a pre-test. Then students were instructed beforehand to come up with at least three questions each of what they wanted to be discussed during the in-class phase of flipping, followed by post-test. Finally, MCQs pre and post-test were given to measure the comparative effectiveness of both the strategies.

For the TBL sessions, students were divided into nine teams comprising five. After the pre-test, the students were instructed to respond to the problem-solving activities via zoom chat in the main teacher's room. Afterwards, they were instructed to go to their respective teams on zoom to do the group readiness activities. Finally, they all reported to the main zoom room of the teacher with the team leaders speaking on behalf of the groups with the responses to the problem-solving activities assigned to them on the same time allotted to all the groups. The right to appeal the decisions was allowed through the chat option. The instructor then gave the feedback and responded to the queries if raised.

Statistical Package for Social Sciences (SPSS) version 20.0 was used for the data analysis. Descriptive statistics were applied to measure frequency, percentages, means and standard deviations. The outcome variable, i.e., mean pre and post-test scores, were compared between the groups, first using independent samples t-test in the case of both study groups. Then, later on, a paired-samples t-test was applied to see the mean difference in the pre and post-test scores. The p-value <0.05 was considered statis-tically significant.

RESULTS

Out of the total 50 cases in each study group, there were 20 (40.0%) males and 30 (60%) females in the TBL group and 23 (46.0%) males and 27 (54.0%) females in the FC group. The average age was 17.4 ± 0.7 years in TBL and 17.3 ± 0.6 years in the FC group. Most students were 17 years of age in TBL 34 (68.0%) and FC group 38 (76.0%) shown in Table-I.

Table-I: Baseline characteristics of students.

Characteristics	Team-based Learning (n=50)	Flipped Classroom (n=50)
Gender		
Male	20 (40.0%)	23 (46.0%)
Female	30 (60.0%)	27 (54.0%)
Age Categories		
17 years of age	34 (68.0%)	38 (76.0%)
18 years of age	11 (22.0%)	8 (16.0%)
19 years of age	5 (10.0%)	4 (8.0%)
Age in years (Mean ± SD)	17.4 ± 0.7	17.3 ± 0.6

Table-II depicted the comparison of test scores after the intervention. It was noted that in the post-intervention period, significant variation between the two educational methods was noted. For example, in session one, after the class, the students from the TBL group achieved significantly higher marks 67.0 ± 10.4 than the FC group 48.3 ± 8.4, proving highly significant differences (p-value <0.001). In session two, the mean test scores were also significantly greater in the TBL group than in the FC (p-value <0.001). Moreover, in the post-session tests, the students from the TBL group continued to achieve better scores in session three and session four (p-value <0.001).

Table-II: Comparison of marks (%) obtained by students of both groups in each session post intervention.

Session	Team-based learning (n=50)	Flipped Classroom (n=50)	p-value
Session One (%)			
Mean ± SD	67.0 ± 10.4	48.3 ± 8.4	<0.001
Session Two (%)			
Mean ± SD	66.5 ± 7.0	55.1 ± 10.1	<0.001
Session Three (%)			
Mean ± SD	60.5 ± 6.7	53.1 ± 5.6	<0.001
Session Four (%)			
Mean ± SD	69.4 ± 3.7	55.1 ± 3.5	<0.001

DISCUSSION

In the context of the evolution of medical education and awareness of the significance of active learning, the method of conducting the class has revolutionized. Flipped classroom and Team-based learning are both active learning methods.[1] A strategic shift in Pakistani undergraduate and post-graduate medical teaching has been observed, but little is reported about establishing their comparative effectiveness in the literature.

The advantages of active learning have been proven in undergraduate and post-graduate medical classes, as Dembovski and colleagues proved that Flipped classroom frameworks improve efficacy in undergraduate practical courses.[9]

In the on-face phase of the flipped class, the given topic is brainstormed and discussed through active student involvement to fill in gaps in knowledge, and the concept is made clearer for the students.[10,11]

As per the study objective, the test scores of students attending the TBL class scored better than the FC group. Numerous trials on the topic have evaluated the role of FC and TBL individually, but fewer studies report on a comparison of both. A study by Nishigawa *et al*, compared flipped classrooms with TBL in prosthodontics students. They found that the termend examination results of TBL classes had comparatively higher scores than in flipped classroom.[1] Another study by Koles and colleagues found a greater impact of TBL classes on students achieving low marks in term examinations. It concluded that medical students' higher performance on examination questions related to course content learned through TBL suggests that TBL enhances mastery of course content.[12] Finally, Ding and colleagues proved that flipped classrooms combined with the team-, case-, lecture- and evidence-based learning (FC-TCLEBL) are better than traditional lecture-based classes for teaching ophthalmology students.[13]

In a broader context, emerging scientific evidence shows that the TBL model may outperform flipping the class, both in terms of acquisition of knowledge and skills. Students especially valued the TBL model's ability to enhance peer learning and facilitation via peer and faculty interactions. In addition, the ability to work in teams and the dynamics of team spirit play a pivotal learning foundation.[12]

Active participation such as simulation, clinical scenarios, PBL, TBL, and discussion activities align well with these core values and have been highly appreciated.[9]

There is also evidence which suggests that both team-based learning and flipped classroom are equally effective in undergraduate medical education. A study by Nakagawa *et al*, witnessed no difference in the endterm examination scores between TBL and FC

educational methods.[14] Therefore, it is considered that both FC and TBL are active educational activities, and students can engage in meaningful self-study.[15]

The difference between FC and TBL is a less explored area of education. Moreover, comparing the pre and post-test scores, it was found that flipped classrooms and TBL achieved significantly higher scores in the post-test in this study. There were other reports similar to this finding. For example, a study by Gupta *et al*, compared traditional lecture-based education with flipped classrooms and found that in the post-class assessment, flipped classroom students achieved significantly higher scores than traditional lecturing ($p<0.001$). Their overall scores were also significantly higher in post-test assessment.[16]

One of the key points in any educational process is students' satisfaction and acceptance of educational methods. Strayer *et al*, performed a comparative study between a flipped classroom and the traditional classroom and demonstrated that students participating in the flipped classroom were less satisfied. This points out that the flipped classroom style may not be acceptable to all audiences and may not apply to all subjects.[17] Moreover, this has been proven by many other medical educationists as well that inverted classroom influences cooperation, innovation and task orientation during a class.[18,19]

Despite varied viewpoints and scientific evidence in comparison, contrast and neutrality, to sum up, the current study proved that TBL has a greater impact in terms of post-session test scores compared to the FC method. Furthermore, this study proved that a subtype of the flipped classroom, i.e., TBL, is superior to flipping the class with a well-prepared audiovisual lecture. In addition, this is one of the very few studies comparing FC and TBL methods in undergraduate studies, especially in teaching Biochemistry. Furthermore, this was an interventional trial where two teaching techniques were compared.

LIMITATIONS OF STUDY

The limitations of the study were essentially related to data collection since the spread of COVID-19 teaching shifted to online exclusively. Issues regarding connectivity, students' compliance with instructions and response, and adapting to online methodology emerged and were tackled. Other limitations of the study included being a single-centre study and having a limited sample and time period.

CONCLUSION

Team-based learning is more effective than flipped classroom learning techniques in teaching biochemistry to undergraduate medical students. This means that working in teams and utilizing peer learning proved superior to self-study by flipping the class with good teaching material and a structured classroom format. The mean test scores were significantly greater in the TBL group than in the FC group in all sessions.

It was observed that students like to collaborate during team activities which were part of the TBL. This was not part of the current study outcomes. However, further studies on the topic taking into view the acceptance and perspective of students regarding these teaching methods need to be done. Moreover, the study needs to be replicated in other institutions, especially post COVID times, since the study was conceived and planned for normal class interaction.

Conflict of Interest: None.

Author's Contribution

AZ: Conception, design of the work, Drafting and write up, RY: Final approval of the version to be published, LRF: Data analysis, RM: Data interpretation, RT: Draft review, SM: Literature search, Data collection

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