

Team-Based Learning and Lecture-Based Learning: Comparison of Sudanese Medical Students' Performance

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Aim: Students' performance in TBL compared to LBL needs to be evaluated. This study aimed to compare students' performance in team-based learning and traditional lectures.

Methods: A total of 176 class 4 and 202 class 6 medical students from University of Bahri, Khartoum, Sudan, participated in the study during 2018. Experienced staff were selected to conduct the teaching and assessment of the two groups, using the standard team-based learning procedure (iRAT, gRAT and AppT) in the first topic and the lecture-based learning procedure in the second, within the same time limit for the two methods.

Results: The two classes overall mean score has a significant 5.1 points difference ($p < 0.001$; 95% CI: 3.5, 6.0). Separate analysis showed consistency of superiority of TBL to LBL in either gender. A remarkable difference was observed when we compared the two methods in class 6 separately from class 4. Class 6 mean score was high for both TBL and LBL (77.2 and 70.2, respectively), with a significant mean difference of 7.0 ($p < 0.001$; 95% CI: 5.1, 8.9). In class 4, the score was lower for both methods (mean of 62.8 for TBL and 59.9 for LBL). The mean difference of 2.95 points was still significant ($p < 0.05$; 95% CI: 0.46, 5.43). Separate multivariate linear regression for TBL and LBL showed no significant difference in performance of males and females in either method. Controlling for gender in TBL, class 4 had a mean of -14.26 points, ($p < 0.001$; 95% CI: -12.54, -15.98) less than class 6. Similarly, in LBL, class 4 had a mean of -10.18 points ($p < 0.001$, 95% CI: -7.02, -13.35), less than class 6.

Conclusion: Students' performance using team-based learning was superior to lecture-based learning, irrespective of students' gender, noticeable among senior students.

Keywords: team-based learning, lecture-based curriculum, medical education, curriculum, assessment

Introduction

The popularity of team-based learning (TBL) among students could be due to many reasons: first, deep learning is established; second, it encourages self-directed learning and avoids just memorization; and lastly, it prepares students to solve problems and fosters teamwork.^{1,2} Although traditional lecture-based learning (LBL) is needed for large groups, team-based learning can be used with large groups, especially when materials are available to students, which promotes critical thinking and encourages teamwork.³⁻⁵ Evidence-based studies support the use of self-directed learning, which could be more beneficial than just giving lectures to provide knowledge.^{6,7} Many authors consider student performance in TBL to be the

same as that in traditional lectures^{8,9}; however, other advantages of TBL could outmatch traditional LBL, for instance in prior knowledge before the class, splitting a large group into small groups without requiring an increased number of faculty, students taking responsibility for their own learning, and enhanced tutor–student relationships.^{10–13} TBL has three steps. Initially, students must work on their reading assignment on a topic chosen by their tutor, who provides references or reading materials based on a timetable. Then on the TBL day, each student immediately answers usually 10 MCQs (ie, individual readiness assurance test [iRAT]). Immediately after that, the same MCQs are answered by a predetermined group (ie, team readiness assurance test (gRAT), then usually five new MCQs are answered by all groups. This final test is called application test (AppT). When all these processes are finished, the students and the tutor discuss the answers to the questions, and finally, the tutor gives a micro lecture.^{12,14–18}

Rationale: In countries with a setup that is similar to ours, where the number of students is increasing and there is shortage of faculty and facilities, TBL may provide an alternative option for assessment as well as teaching strategy to improve learning in medical schools.

Objectives of this study: to compare student performance in team-based learning and that in traditional lecture-based learning, where TBL is possible in both preclinical and clinical phases.

Our research question is whether there are any differences in student performance between team-based learning and traditional lecture-based learning, ie, is peer performance is better than individual performance.

Methods

Study Design, Setting, and Participants

Participants in this intervention study were fourth-year and sixth-year medical students at University of Bahri in Khartoum, Sudan, during the academic year 2018–2019. The university implements a curriculum that uses different teaching strategies, but mainly lectures and a hybrid problem-based learning (PBL). The fourth-year students (n=225) have passed the preliminary basic sciences of anatomy, physiology, and biochemistry; and the study was conducted in the pathology course. The sixth-year students (n=220), on the other hand, have completed all the basic sciences, and enrolled in major clinical courses. The experts based the selection for sixth- and fourth-year

students for the study on the following assumption. The fourth year in the midway after intermediate and can reasonably judges what learning methodology will fit them rather than second- or third-, while sixth-year students can be in a better position to tell which is the best after they finished their presumed program. The study was conducted on their pediatrics course. All the students had no previous experience with TBL, but they were familiar with lectures.

Procedure

The students from both classes were oriented in advance about TBL and traditional lectures as educational interventions. The study objectives were explained to them, and it was made clear that their participation was optional. Two specialized faculty members conducted the orientation about TBL in both classes. The students who opted to participate in the study were 176 from class 4 and 202 from class 6 with a response rate of 78.2% and 91.8%, respectively.

TBL Intervention

The objectives and contents for the topic of nephrotic syndrome were explained to all the sixth-year students participating in the study using PowerPoint slides and pamphlets. The pathology of skin tumors was explained in the same manner to the fourth-year students. TBL was used for over 2 hours in both classes. The students did their reading 1 week before the TBL workshop, and then at a specified day, each student answered the individual readiness assurance test (iRAT). The tutor then randomly divided class 4 students into 10 groups and class 6 students into 8. Then, the students answered the same test in consensus as a group (gRAT). After collecting the answer sheets from both tests, the tutor administered the application test, where the groups were given cards that contained answer choices and the correct answer card would be raised by each group after the discussion and then the tutor would record the results and assign scores to each group. This was labeled as Application Test (AppT).

LBL Intervention

In the lecture-based intervention, different topics were selected: sickle cell anemia for class 6 students and brain tumors for class 4 students. The same TBL tutor delivered the lecture for the two classes and spent the same period of time as for TBL. The lectures were conducted as conventional ones using visual aids in the form of a PowerPoint

presentation, emphasizing the objectives and encouraging the students to ask questions. Then, the students were asked to individually answer the test (TrT).

Measuring Outcome

The iRAT, gRAT, and AppT scores were used to measure the outcome of the students' learning when the TBL intervention was used, whereas the TrT score was used to measure the learning outcome when the traditional lecture intervention was used. The total score for iRAT was 50, that for gRAT was 30, and that for AppT was 20, collectively making a total score of 100 (total TBL). The outcome for the traditional lecture-based learning was measured using a test with a total score of 100. The tests consisted of questions with a scenario-based, single best correct answer. All the students were not aware that the questions for iRAT, gRAT, and AppT were the same but arranged in different orders.

Statistical Analysis

Data were coded, entered, summarized and analyzed using SPSS software version 21. Categorical and nominal variables were expressed as frequencies and percentages. The Shapiro–Wilk test was used to test the normal distribution of the test scores. Paired sample *t*-test and linear regression were used to compare quantitative data. A *p*-value of <0.05 was considered significant.

Results

A reliability analysis was carried out on the 4 test scores for TBL, iRAT, gRAT and Appt, and the total summation of all of them (total TBL). Cronbach's α showed that the different modalities of TBL test scores had acceptable reliability, $\alpha = 0.69$. A lower, however acceptable, value of reliability (Cronbach's $\alpha=0.58$) was obtained when the analysis was carried out on the 10 test scores altogether including scores for LBL. Most tests seemed worth of retention because alpha value was decreased when any of the tests were deleted from the items' total statistics.

The overall performance results showed a mean score of 70.5 for TBL and 65.4 for LBL in the combined class 4 and class 6. The mean difference in scores (5.0 marks) was significant ($p<0.001$, 95% CI: 3.5, 6.0). The histogram (with moderate skewing to the left) showed that many more students failed to score above 60% in LBL compared to TBL (Figure 1).

We performed analyses for all the females (312) and all the males (66) separately and observed a consistency of

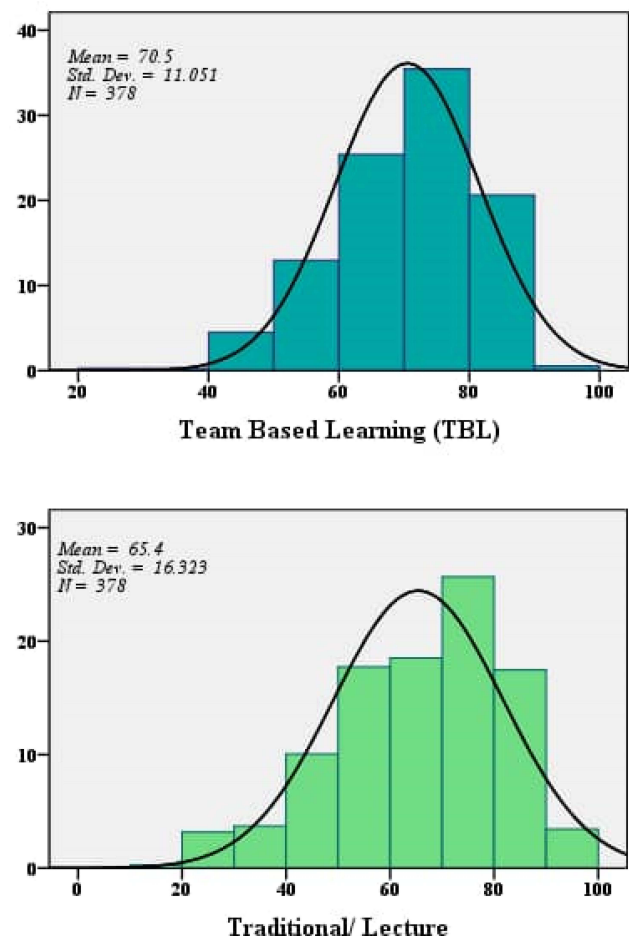


Figure 1 Comparison of students' scores in the tests following TBL and LBL.

the superiority of TBL to LBL in either gender. The mean score was 71.0 for TBL and 66.0 for LBL in the female classes with a mean difference of 5.1 (p -value <0.001 , 95% CI: 3.3, 6.8). Male classes, on the other hand, showed a slightly lower mean score in both TBL (68.1) and LBL (62.8). Nevertheless, the mean difference of 5.3 points, was significant ($p<0.001$, 95% CI: 2.1, 8.5), Table 1.

A remarkable difference in the results was observed when we compared the two methods in class 6 separately from class 4. The class 6 mean score was high for both TBL and LBL (77.2 and 70.2, respectively) with a significant mean difference of 7.0 points ($p<0.001$, 95% CI 5.1, 8.9). In class 4, the score was lower for both methods (mean 62.8 for TBL and 59.9 for LBL). The mean difference was 2.95 ($p<0.05$; 95% CI: 0.46, 5.43), as shown in Table 2.

We performed a stratified analysis to compare the differences in the mean scores of the two methods by gender and class. The mean scores and difference continued to be highly

Table 1 Paired t-Test Comparing Scores of TBL and LBL Among Male (n=66) and Female (n=312) Students

Variable	Mean		Standard Error		95% CI	
	M	F	M	F	M	F
TBL	68.1	71.02	1.3	0.63	65.4–70.7	69.78–72.25
LBL	62.8	65.96	1.9	0.93	59.0–66.5	64.13–67.80
Difference	5.3	5.05	1.6	0.89	2.1–8.5	3.29–6.81
Paired t-test	3.3	5.6				
2-Sided P value	<0.01	<0.001				

Abbreviations: CI, confidence interval; TBL, team-based learning; LBL, lecture-based learning; M, male; F, female.

Table 2 Paired t-Test Comparing Scores of TBL and LBL Among Students of Class 6 (n=202) and Class 4 (n=176)

Variable	Mean		Standard Error		95% CI	
	Class 6	Class 4	Class 6	Class 4	Class 6	Class 4
TBL	77.18	62.84	0.41	0.80	76.37–77.99	61.25–64.42
LBL	70.21	59.89	1.01	1.26	68.22–72.20	57.39–62.38
Difference	6.97	2.95	0.97	1.26	5.05–8.88	0.46–5.43
Paired t-test	7.16	2.34				
2-Sided P value	< 0.001	< 0.05				

Abbreviations: TBL, team-based learning; LBL, lecture-based learning.

significant for both the females and the males in class 6. Females scored 77.4 and 70.5 in TBL and LBL, respectively, with mean difference 6.7 ($p < 0.001$, 95% CI: 4.8, 9.0), while males scored 76.0 and 68.7 in TBL and LBL respectively with mean difference 7.3 ($p < 0.01$, 95% CI: 2.8, 11.8). The mean scores and the difference in the mean scores in class 4 was not significant for the females (mean difference 2.7; $p = 0.07$, 95% CI: -0.22, 5.64), nor was it significant for the males (mean difference 3.82; $p = 0.10$, 95% CI: -0.79, 8.42).

To control any confounding effect of gender and class on student performance, we used a multivariate linear regression model to estimate the mean expected performance of TBL and LBL. The estimated mean score for LBL was 59.1 (95% CI: 57.5, 60.8) for a female in fourth Class. Males scored an average of 1.5 points less than females but were not significant. On average, students scored 12.2 points more if they were in class 6 compared to class 4 (95% CI: 10.4, 14.0, $p < 0.001$). While controlling the effect of gender and class, students scored an average of 5.1 points higher when taught through TBL, compared to LBL (95% CI: 3.3, 6.9, $p < 0.001$), Table 3.

Table 3 Multiple Linear Regression for Expected Performance Score

Model	Coefficients		t	P value	95.0% Confidence Interval
	B	Standard Error			
Constant*	59.1	0.85	69.7	<0.001	57.5 to 60.8
Gender	-1.5	1.20	-1.2	0.229	-3.8 to 0.9
Class	12.2	0.92	13.3	<0.001	10.4 to 14.0
Method	5.1	0.91	5.6	<0.001	3.3 to 6.9

Notes: Gender: Male = 1, Female = 0; Class: 6th = 1, 4th = 0; Method: TBL = 1, LBL = 0. *Constant = mean score of fourth-class female student in LBL.

Discussion

To the best of our knowledge, this is the only available study in Sudan that outlines the quality of student performance in TBL versus traditional lecturing. TBL was consistently superior in student performance to LBL, irrespective of the gender of the students, as there was no significant difference in performance by gender, in either class. More students in TBL scored higher marks. However, this higher TBL performance was evident in class 6. It seems that TBL is more stable and beneficial to senior medical students. Perhaps, it

required students who are more experienced and independent learners, as well as team workers with a greater sense of responsibility toward their academic work. These findings could be explained by the good preparation before the test, which affects performance in iRAT, and the collaboration among the team members during gRAT. In fact, several studies have documented that students performed better in TBL than in LBL,^{19,20} the results of the study of Reagans, Argote, and Brooks (2005), who used authentic TBL in the workplace.²¹ Also, this study is in harmony with that of Edmondson, Winslow, Bohmer, and Pisano (2003), who reported that TBL enhances knowledge among team members.²² It is consistent with study done among medical students (males and females) at the Boonshoft School of Medicine (2004–2005), which adopted a curriculum similar to that of the University of Bahri's College of Medicine.²³ The findings here are similar with the study done among medical students at Wright State University when their performance by TBL was compared to that of students who took the traditional method of teaching.²⁴ There was correspondence with study on dental students at the University of Florida which showed that students who received knowledge through TBL did well in their examination and retained knowledge for a long time, which allowed them to do well in the workplace compared to learning through traditional LBL.²⁵ Our study is analogous with those of Yan et al, at the Medical School of Chifeng in the People's Republic of China, which reported higher TBL examination scores compared with traditional lecture examination scores (81.70 ± 8.53 vs 74.41 ± 8.27 , $p < 0.01$) and higher marks reported in TBL compared with those in LBL and conventional tutorial (CT) groups as shown in Hashikar.^{25,26} There is some resemblance with the results of an Indian study conducted on students from a college of pharmacology.²⁷ Finally, it is obvious that TBL supports collaborative learning through teams, which is reflected by different studies.²⁸

While in our setup senior students performed better than junior ones, still, our junior students performed well in TBL, which is comparable to the findings of other studies.²⁹ TBL, with the higher performance, compared with traditional lectures, will set a high standard, a factor that could ensure social accountability and good quality of doctors.^{30–33} Our study showed that females and males performed similarly, in TBL and LBL. The slightly higher scores of females in both methods were not statistically significant. However, at Maulana Azad Medical College in India, TBL was observed to be an effective learning tool

for females and high achievers.^{18,29,34} The findings that TBL was superior to traditional lectures are supported by many studies; however, this depends on students' positive perception of TBL,³⁵ interaction between students, changing experiences among students and the collaborative nature of TBL,²⁸ enhanced communication, professionalism, self-directed learning, critical thinking, and knowledge application.³⁰ Finally, recent studies by many authors support this study, pointed out the valuable advantages of it and recommended it for implantation in learning.^{36–39}

Limitations

This comparison of student performance through exposures to TBL and LBL was based on the assessment of each group using iRAT, gRAT, Appt for TBL and classical assessment for LBL (MCQs, etc). A true difference in performance can only be evaluated if graduates who are products of the two methods were assessed using a standard assessment for both educational techniques. Later in service, evaluation could reflect how much knowledge and skills were retained from being trained using these two different educational methods. Moreover, this comparison was only made on selected topics in only two disciplines rather than on full courses, besides large number of the small groups. In this paper, we did not study the student perspectives and we recommend further studies to consider this point.

Conclusion

Medical students' performance using team-based learning was consistently superior to traditional lecture-based learning, irrespective of students' gender. Senior medical students scored better than junior students following team-based learning. The study highlighted a solution to an educational process in countries with low resources.

Ethical Approval and Consent

The ethical approval of the study was obtained from the University of Bahri Research and Ethical Committee (UB-REC). All participants have provided written informed consent. This study complies with the Declaration of Helsinki.

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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.

Disclosure

The authors report no conflicts of interest in this work.

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