ORIGINAL ARTICLE

The Outcomes of Team-based Learning on Test Performance, Cognitive Engagement and Motivation in Preclinical Anatomy Practical Classes

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ABSTRACT

Introduction: Designing an engaging teaching strategy that enhances the clinical application of anatomy knowledge is important for effective learning. Hence, this study was carried out to evaluate the outcomes of team-based learning (TBL) approach on students' learning during gross anatomy practical classes. **Method:** A randomised-controlled trial was conducted on 215 pre-clinical year medical students, who were divided into TBL and control groups. Both groups attended the same anatomy lecture before the practical session. The TBL group underwent three phases of activities, which were pre-practical assignment (Phase-1), individual and team readiness assurance tests followed by a debriefing session (Phase-2), and group application task (Phase-3). Concurrently, the control group received a reading material as their pre-practical assignment and attended a practical session in the form of an anatomy model demonstration. Pre- and post-practical assessments were measured 30 minutes before and after the practical sessions. The students' cognitive engagement and motivation were also measured after the practical sessions. **Results:** The TBL group among the Year-1 students outperformed the control group in all the test performance measures. The TBL group of the Year-1 students was also found to have greater improvement of test scores compared to their control counterparts. The TBL group was found to have significantly higher cognitive engagement scores only among the Year-2 students. However, the internal motivation scores were not significant in both cohorts. **Conclusion:** These results indicate that the TBL session contributes positive outcomes to students' learning in anatomy context.

Keywords: Team-based learning, Gross anatomy practical, Test performance, Cognitive engagement, Internal motivation

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INTRODUCTION

Acquiring a firm comprehension of gross anatomy knowledge is pertinent for medical students as it is the core basic sciences knowledge with high clinical relevancy (1,2). Medical students are required to have adequate anatomy knowledge to ensure successful development and retention of clinical skills (3). Nevertheless, teaching anatomy in the modern medical curriculum is often with challenges. Ever since the medical education reform in the early 20th century, the anatomy curriculum has undergone evolutions in terms of content and teaching methods (4). The content and teaching hours of anatomy syllabus have been reduced to accommodate new medical subjects such as genetics and integrative medicine (5). Within the compressed curriculum, it is becoming more challenging to conduct cadaveric dissection – a student-centred method for learning anatomy knowledge, skills and value (6) – as the primary teaching method in anatomy, despite being favoured by medical students and lecturers (7). Over the past few decades, cadaveric dissection has been replaced by multiple teaching strategies, including demonstration using anatomy plastic models, computer assisted-learning, radiographic imaging, and three-dimensional anatomy software (8,9). These forms of anatomy learning are often implemented as activities in practical sessions, which supplements the lectures. Alongside the theoretical knowledge captured from the lecture, efforts should be made to attain other learning attributes such as affective and psychomotor learning competencies from the practical session (10).

Nevertheless, none of the teaching approaches seem to be effective over another pertaining to the achievement of the learning outcomes (11). To achieve the cognitive, psychomotor, and affective learning outcomes, it is important to adopt the student-centred and interactive learning elements into the teaching methods to ensure students actively engaged with the learning process (12). The transition of active learning pedagogy from the traditional learning method is outstanding and promotes positive impacts on learning performance (13). Notwithstanding the importance of having new teaching methods in anatomy education, the implementation of new strategies in any institution can meet various challenges such as limited facilities and resistance from educators. Thus, it is necessary to provide evidence demonstrating the efficacy of the new teaching modality, which is achieved through conduction of studies.

One of the promising teaching methods that could cater for cognitive, psychomotor, and affective learning is the team-based learning (TBL) approach. TBL is a structured instructional strategy that incorporates active learning and emphasises small group teaching and learning activities in a cohort of large students setting (14). During its inception, TBL was implemented only for business administration courses (15). Subsequently, TBL has been extensively applied in various disciplines including medical programs (16–18). Generally, TBL comprises of well-structured learning activities that span over three phases: The Phase 1 of TBL includes an individual preparation that will be carried out by all students in the team; Phase 2 involves assessment of individual's and team's knowledge on the materials that they have learned during their preparation phase that were followed by a feedback session; and Phase 3 involves group work task (19). During Phase 1 of TBL, students will be assigned a task or activity that serves as an individual preparation before they work in a team. After accomplishing the prior preparation task, the students will undergo various activities in Phase 2 (20). This phase usually begins with an assessment of knowledge on the learned topic, which is measured individually through the individual readiness assurance test (i-RAT); and collectively through the team readiness assurance test (t-RAT) (20). During the t-RAT assessment, students are required to provide a consensus of answers to the questions (20). The subsequent activity in the second phase of TBL is the debriefing session, whereby a lecturer or tutor will provide feedback to clarify any problems or misconceptions that could arise during the learning process (20). Throughout this clarifying feedback activity, the students are allowed to conduct a team appeal process, whereby they can defend their answers by providing evidence-based statements as their justification (20). Once the students are satisfied with their achievement in the second phase, they can proceed to phase 3 of TBL, whereby they are required to work together as a team in a group application problem (GAP) task. The GAP task evaluates the students' ability to apply their knowledge in a relevant context and integrate their knowledge for the development of psychomotor skills (20).

In the anatomy education context, there is growing interest among anatomy educators to use this innovative method in teaching anatomy courses, which are often taught during the first and second year of the curriculum. Several published articles reported the benefits of TBL application in anatomy courses for medical and allied health sciences students (21,22). It was noted that teaching anatomy subjects using TBL method had resulted in the effective acquisition of topographical anatomical knowledge, increase students' motivation to do continuous self-revision on anatomy subject, and increase the weak students' ability to learn difficult anatomy contents (22–24). Nevertheless, evidence was scarce on the implementation of TBL methods in pre-clinical anatomy courses that emphasise on the clinical applied anatomy content. There is also limited studies on the effects of TBL application on students' cognitive engagement and motivation to learn, particularly in anatomy context. Hence, this study was set out to fill in these gaps in the context of gross anatomy practical that utilises clinically applied anatomy. This study addresses three research questions: (1) What is the effect of TBL gross anatomy practical on the preclinical Year 1 and Year 2 medical students' test performance?; (2) What is the effect of TBL anatomy practical on the preclinical Year 1 and Year 2 medical students' cognitive engagement?; and (3) What is the effect of TBL anatomy practical on the preclinical Year 1 and Year 2 medical students' motivation to learn?

MATERIALS AND METHODS

Ethical approval

Ethical approval was obtained from the Human Research Ethics Committee of the Universiti Sains Malaysia (USM/JEPeM/18030169). Since the participants are subjected to the institutional vulnerability, a briefing session on the purpose, participation criteria, methodology, benefits, risk, confidentiality, subjects' privacy, and method of termination were conducted before the subject recruitment. The students were informed that their participation was voluntary, and they were free to withdraw at any time as they wish without affecting their progress in the medical course. The method of withdrawal was made explicit to the participants and the control group was offered a TBL anatomy session after the study had ended.

Study design, population, sampling method, and subjects

A randomised-controlled trial with a parallel design was implemented in this study. Our study population was the pre-clinical year – that consist of the Year 1 and Year 2 – Universiti Sains Malaysia (USM)'s medical students of the 2018/2019 academic session. A purposive with homogenous sampling method was applied; and out of 278 students, 215 agreed to participate in this study.

Participation was voluntarily and written consent was obtained before the study.

Research groups

The consented students were divided into two groups; TBL and control groups. In order to control the confounding factors (i.e., gender and English proficiency), group allocation was performed using a stratified random allocation method. Through this method, each group contains an almost equal number of subjects with the same confounding factor (i.e., male, female, band scores for Malaysian University English Test [MUET]). The students in the TBL group were exposed to the TBL gross anatomy practical class. In contrast, those in the control group were exposed to the usual gross anatomy practical class, whereby they attended a demonstration of anatomical structures using plastic anatomy models, followed by a self-study session.

Research tools

Pre- and post-practical tests

Two gross anatomy topics – one topic each from the Year-1 and Year-2 medical syllabus – were selected for this study. The first-year medical students attended the practical session on 'The gross anatomy of the lower respiratory tract and diaphragm', while the second-year students attended the practical session on 'The gross anatomy of the female reproductive system', following the respectives lectures. The topics were selected on the basis that the students have no prior exposure to the topic before the conduction of the study; and these topics have a significant amount of clinical applied content. The students' test performance was measured through the objective structured practical examinations (OSPE). Two sets of OSPE (i.e., the two sets were the pre-practical and post-practical tests) comprising of three anatomy questions, were used to measure the students' test performance 30 minutes before and after each practical session. The three questions used in the pre-practical and post-practical tests are similar, except that the arrangement of questions and their respective items were rearranged in a different order to avoid pattern memorisation effect. The questions were developed based on the learning outcomes of the topics and they assessed the students' anatomical knowledge on structure identification and their related clinical application. These questions were prepared by two qualified senior anatomy lecturers and were vetted by a panel of medical lecturers consisting of anatomists and medical educationists.

Individual and team readiness assurance test (i-RAT and t-RAT) questions

Two questions on the anatomical structures identification and their clinical applied knowledge were constructed by two senior anatomy lecturers for the readiness assurance tests. The same sets of questions were used for i-RAT and t-RAT. The questions were vetted by a panel of medical lecturers consisting of anatomists and medical educationists. Since these questions were part of the learning materials in the TBL group, the marks obtained by the students were not included for statistical comparison.

Group application problem (GAP) question

A challenging and ill-defined case-based scenario with five open ended questions were constructed by two senior anatomy lecturers. The questions assessed the students' critical thinking and ability to apply their knowledge in relevant contexts. The questions were vetted by a panel of medical lecturers consisting of anatomists and medical educationists. These questions were used for learning activities in the TBL group and the marks obtained by the students were not included for data comparison.

Learners' engagement and motivation questionnaire (LEMQ)

Apart from that, the students' motivation and engagement scores were measured using the validated Learners' Engagement and Motivation Questionnaire (LEMQ) (25). The inventory contains two constructs, which are cognitive engagement and internal motivation. The cognitive engagement construct overlies five items that were developed by Webster and Ho (26). While the internal motivation construct is represented by 12 items that were obtained from the 'effort and importance' and 'value and usefulness' of the validated Intrinsic Motivation Inventory (27). The questionnaire was distributed to the students immediately after the practical session and they were asked to rate their perceptions of the listed items.

The intervention and data collection

Three days before the intervention, specific pre-class assignments were distributed to the students immediately after the lecture session. The students in the TBL group received the pre-class assignment in the form of structure identification questions and completion of worksheets. Meanwhile, the control group students received a reading assignment related to the selected topic. To ensure students in the TBL group had performed the pre-class assignment, they were required to submit the pre-class assignment before the practical session. Conversely, reading assignments for the control group were intended to reflect the authentic students' learning situation, whereby they usually have a lack of motivation to do pre-reading before the actual class (28).

On the practical day session, all students underwent a pre-practical test – in the form of OSPE that measured their baseline knowledge – which was conducted within 30 minutes before the practical session. Subsequently, both groups attended their respective practical sessions. The TBL group attended the TBL gross anatomy practical, while the control group attended the usual anatomy practical class. The TBL session began with the Phase 2 activities, whereby the students answered the questions in the i-RAT individually, and followed by team discussion in t-RAT. During the t-RAT, the students were required to discuss the questions among their team members to come out with a consensus of answers. Subsequently, they were assessed on the critical thinking and clinical knowledge application skills in the GAP task, whereby they were exposed to a challenging and ill-defined case-based scenario question. The TBL practical session ended with a debriefing session by a lecturer, who discussed the answers, clarified any misconception, and provided feedback to the students. The process of TBL practical session is illustrated in Fig.1. Meanwhile, the control group attended the usual practical session, whereby the respective lecturers demonstrated the anatomical structures using the plastic anatomy models. The demonstration was followed by a self-study session, whereby students were free to use the models for revision.

Figure 1: The process of TBL practical session. The students were answering i-RAT questions individually (A), the students were discussing in the team for t-RAT activity (B, C, and D), the students were discussing in the team for GAP task (E), and debriefing session by the respective lecturer (F).

Two senior anatomy lecturers were involved in moderating the whole study process. However, to reduce the lecturers' bias, the whole study process for each anatomy topic (i.e., Year-1 and Year-2 topics) was handled by one lecturer only. The lecturer delivered the lecture to all the participants, provided the debriefing session to the TBL group, and delivered the demonstration session to the control groups. The role of the lecturer in TBL practical was as a mere facilitator, who conducted the debriefing session at the end of the TBL practical. Therefore, the lecturer had enough time to deliver a demonstration session to the control group, which was conducted concurrently with the TBL practical. Besides that, one tutor was available in each practical to facilitate the teaching and learning session.

After both groups had completed the practical sessions, they underwent a post-practical test that evaluated their understandings of the related topics. Lastly, all participants were required to fill up the Learners' Engagement and Motivation Questionnaire (LEMQ). The flow of this study is summarised in Fig 2.

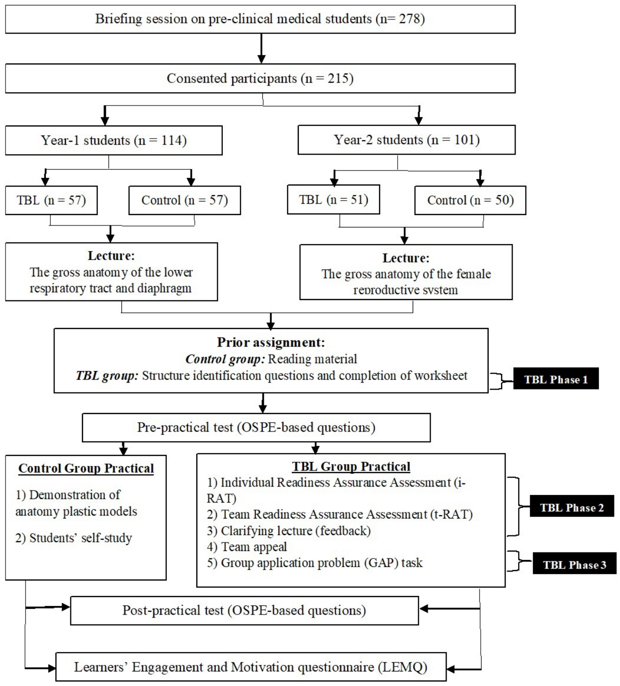

Figure 2: The study flowchart

Data analysis

Statistical analyses (Independent-t test, Mann Whitney test and Paired t-test) were performed using Statistical Package for the Social Sciences (SPSS) software, version 24 (IBM Corp., Armonk, New York). The data were entered, checked for data entry error and missing values, explored, and cleaned. To avoid biased estimates in data analysis, missing values were imputed with observed median values for cases of less than 50% missing value (29). Before running the statistical assessment, the assumption for each assessment was checked and the level of significance (α) was set at 0.05 with a confidence interval of 95%. Cohen effect size was calculated using the Effect Size Calculator for T-Test (Social Science Statistics, Toronto, Canada) to investigate the actual impact of the intervention on the test scores.

RESULTS

Our analyses revealed different findings between the Year-1 and Year-2 student cohorts. Among the Year-1 students, the pre-practical and post-practical test scores of the TBL group were found to be significantly higher compared to the control group (Table I). While the Year-2 students seem to receive fewer benefits from the TBL practical as there were no significant differences in the

Table I: Differences of the test performance scores between TBL and control groups

Year	Assessment	Score Mean (SD)		t-stats (df)	p-value	95% CI		Cohen effect size (d)
		TBL *(n = 57)*	**Control** *(n=57)*			**Lower**	**Upper**	
Year 1	Pre-practical assessment score	11.82 (5.24)	7.72 (4.21)	4.61 (112)	<0.001	2.34	5.87	0.86
	Post-practical assessment score	62.18 (4.25)	17.67 (4.64)	4.95 (112)	<0.001	2.47	5.77	0.93
Year 2	Pre-practical assessment score	18.08 (4.77)	16.82 (4.70)	1.34 (99)	0.184	-0.61	3.13	0.27
	Post-practical assessment score	23.26 (3.31)	23.02 (2.92)	0.39 (99)	0.695	-0.99	1.48	0.08

Independent t-test was applied to determine mean difference between the study groups. Significance level was set at 0.05. SD = standard deviation; df = degree of freedom; CI= confidence interval. Cohen effect size was calculated using effect size calculator for t-test. Cohen effect size threshold: small=0.20; medium= 0.50 and large= 0.8, very large=1.13.

pre-practical and post-practical test scores between TBL and control groups (Table I).

Nevertheless, improvement in the test scores was found to be highly significant within TBL and control groups of the Year-1 and Year-2 students. These findings reflect that both TBL and anatomy model demonstration practical sessions had successfully increased the students' anatomy knowledge. Following the TBL practical session, the mean test performance scores of the TBL group among Year-1 and Year-2 students improved from 11.82% to 62.18%; and from 18.08% to 23.26% respectively. On the other hand, the improvement of the test scores after the anatomy model demonstration practical session among the Year-1 and Year-2 students was found to be lower than the TBL group. The test scores of the control groups among the Year-1 and Year-2 students improved from 7.72% to 17.67%; and 16.82% to 23.02% respectively. Interestingly, it was found that Year-1 students experienced more than 9.00% improvement of the test scores for both TBL and control groups. While, the improvement of the test scores of the Year-2 students for both TBL and control groups were found to be at a lower range, which was between 5.19% and 6.20% respectively. In addition, the difference of the test performances scores among students in TBL group were significantly higher in the Year 1 compared to the Year 2 students. These results indicate that TBL practical is not superior to anatomy model demonstration practical in terms of promoting the improvement in the test scores. These results are summarized in Table III. Differences of the test performance scores between Year 1 and Year 2 students in TBL groups.

Despite the positive test performance of the TBL group among the Year-1 students, it was noted that their cognitive engagement score was not significant (Table IV). On the contrary, the engagement score of Year-2 students who underwent the TBL practical was found to be significantly higher than the control group despite no significant difference in the test performance scores (Table IV). Likewise, the TBL practical seems to have no impact on the students' motivation level, evidenced by the insignificant difference of the motivation scores between TBL and control groups in both Year-1 and Year-2 cohorts (Table V).

Table II: Improvement of the test scores within and between TBL and control groups of Year 1 and Year 2 students

[a]Year (n)	Group (n)	Test scores (%) Mean (SD)		Difference score, Mean	t-stats (df)	*p*-value	(95% CI)
		Pre	**Post**				
Year 1 (n=114)	TBL (n= 57)	11.82 (5.24)	62.18 (4.25)	-9.96	-19.20 (56)	< 0.001	(-11.00, -8.93)
	Control (n= 57)	7.72 (4.21)	17.67 (4.64)	-9.95	-20.16 (56)	< 0.001	(-10.94, -8.96)
Year 2 (n= 101)	TBL (n=51)	18.08 (4.77)	23.26 (3.31)	-5.19	-9.07 (50)	< 0.001	(-6.33, -4.04)
	Control (n=50)	16.82 (4.70)	23.02 (2.92)	-6.20	-10.92 (49)	< 0.001	(-7.34, -5.06)
[b]Year (n)	**Group (n)**	**Test scores change Mean (SD)**			**t-stats (df)**	***p*-value**	**(95% CI)**
Year 1 (n=114)	TBL (n= 57)	33.21 (13.06)			0.024 (112)	0.980	(-14.67, -4.79)
	Control (n= 57)	33.16 (12.41)					
Year 2 (n= 101)	TBL (n=51)	17.29 (13.61)			-1.26 (99)	0.211	(-8.71, 1.95)
	Control (n=50)	20.67 (13.38)					

[a]Paired-t-test and [b]Independent t-test were applied to determine the change in the test scores within and between groups. Significant level was set at 0.05. SD = Standard deviation; df = Degree of freedom; CI = Confidence interval.

Table III: Differences of the test performance scores between Year 1 and Year 2 students in TBL groups

Year	Difference of test scores Mean (SD)	t-stats (df)	p-value	95% CI Lower	95% CI Upper
Year 1 (n=57)	33.22 (13.06)	6.20 (106)	<0.001	10.82	21.02
Year 2 (n=51)	17.29 (13.61)				

Independent t-test was applied to determine mean difference between the study groups. Significance level was set at 0.05. SD = standard deviation; df = degree of freedom; CI= confidence interval. Cohen effect size was calculated using effect size calculator for t-test (Statistics, 2015). Cohen effect size threshold: small=0.20; medium= 0.50 and large= 0.8, very large=1.13 (Cohen, 1988).

Table IV: Difference of engagement score between the study groups among the Year 1 and Year 2 students

[a]Year 1	Engagement score Median (IQR)	Z-stats	p-value	Cohen effect size (d)		
TBL *(n = 57)*	59.57 (10.00)	-0.672	0.50	0.12		
Control *(n=57)*	55.43 (8.00)					
[b]Year 2	**Engagement score Mean (SD)**	**t-stats (df)**	**p-value**	**95% CI Lower**	**95% CI Upper**	**Cohen effect size (d)**
TBL *(n = 51)*	35.57 (5.67)	2.31 (99)	0.023	0.41	5.37	0.46
Control *(n=50)*	32.68 (6.84)					

[a]Mann-Whitney and [b]Independent t-tests were applied to determine the difference between the study groups. Significance level was set at 0.05. IQR = Interquartile range. Cohen effect size was calculated using effect size calculator for test (Statistics, 2015). Cohen effect size threshold: small=0.20; medium= 0.50 and large= 0.8, very large=1.13 (Cohen, 1988).

Table IV: Difference of motivation score between the study groups among the Year 1 and Year 2 students

[a]Year 1	Motivation score Median (IQR)	Z-stats	p-value	Cohen effect size (d)		
TBL *(n = 57)*	60.74 (14.00)	-1.047	0.30	0.12		
Control *(n=57)*	54.26 (11.00)					
[b]Year 2	**Motivation score Mean (SD)**	**t-stats (df)**	**p-value**	**95% CI Lower**	**95% CI Upper**	**Cohen effect size (d)**
TBL *(n = 51)*	67.71 (8.45)	1.54 (99	0.127	-0.79	6.29	0.31
Control *(n=50)*	64.97 (9.46)					

[a]Mann-Whitney and [b]Independent t-tests were applied to determine the difference between the study groups. Significance level was set at 0.05. IQR = Interquartile range. Cohen effect size was calculated using effect size calculator for test (Statistics, 2015). Cohen effect size threshold: small=0.20; medium= 0.50 and large= 0.8, very large=1.13 (Cohen, 1988).

DISCUSSION

This study contributed four important findings to the body of literature about the gross anatomy practical session through TBL application and demonstration of anatomical structures using the plastic models. First, the Year-1 students seem to be benefitting more from the TBL session because of the greater improvement of the test performance score in the Year-1 TBL group compared to that of Year-2 TBL group. Second, both practical sessions, either TBL or demonstration sessions, had significantly contributed to the improvement of the test scores, with the percentage of improvement were higher in the TBL compared to the control groups for both cohorts. Third, the Year-2 students were more engaged in the TBL learning activities compared to their control counterparts, despite the insignificant difference of their test performance. Finally, the TBL session failed to instil internal motivation towards learning anatomy among the Year-1 and Year-2 students,.

The Year-1 students who attended the TBL session had acquired higher baseline knowledge evident by the higher pre-practical test score compared to the control group. In this situation, the acquisition of baseline knowledge occurred before the introduction of collaborative teamwork elements of TBL through the implementation of the interactive pre-class assignment. Although it could be argued that the different forms of pre-class assignment could have contributed to the result, this study proved that a structured pre-class assignment – which is considered as one of the TBL strategies – that promotes students' participation is important to stimulate their prior knowledge. The control group students who were given a text reading material as their pre-class assignment might not be motivated to read the text before the practical because of the unstructured form of the assignment, and thus resulted in the significantly lower pre-practical test scores. Indeed, there is a vast number of literature supporting the positive impact of the pre-class activities on students' baseline knowledge. Among them is a study by Wolff et al (30) that reported enhancement of students' preparedness through a pre-learning activity, as this activity promoted students' responsibility on managing their own learning needs. Likewise, a study by Hadie et al (31) reported that a pre-lecture activity in the form of video viewing had successfully instilled some prior knowledge before they entered the actual lecture. Therefore, raising students' awareness of the implementation of pre-learning activity before any formal class is pertinent (32). Moreover, an assigned pre-class preparation – as implemented in this study – would enforce students to search for relevant materials on related topics to complete the given task.

In addition to that, the post–practical test score in this study reflects the level of knowledge acquisition and self-perceived learning acquired by the students after the practical sessions. In other words, the score showed how much the students have understood the content learned during the respective practical sessions. In this study, it was predicted that the higher post-practical test score of the TBL group among Year-1 students was influenced by the collaborative teamwork element of this method, which perhaps contributed to better students' learning performance. The TBL session provides a dynamic learning environment, wherein students can collaborate and supplement each other's knowledge and learning skills through in-class group discussion activities, which are in the form of t-RAT and GAP tasks. This postulation is supported by a few studies; one of them mentioned TBL as a highly structured form of collaborative active learning that enhanced the students' interaction to communicate the ideas effectively, construct arguments to support their understanding and clear out common misconceptions together (14). This was supported by another study that reported better students' performance during group discussion, evident by the significantly higher score in the group readiness assurance test compared to their individual test (33).

Interestingly, the pre- and post-practical test scores of Year-2 students were found to be insignificant between TBL and control groups. Despite the effort to control the confounding factors and bias, the TBL session was found to be not superior to the usual demonstration session when evaluated among the Year-2 students. Although there is a limited study that evaluated the impact of TBL among a different cohort of students with different levels of expertise, studies have shown that weaker students benefited more from TBL compared to the good students (24,34). Perhaps, the results reflect that Year-2 students – who have more experience in learning anatomy compared to Year-1 students – were already familiarised with the demonstration and self-study sessions as they have been exposed to these sessions during their previous classes. This form of deliberate practice has been reported to cause results in the acquisition of skills and expert performance (35). Another possible postulation to these results would be the expertise reversal effect of the cognitive load theory. The expertise reversal effect describes the decline in the effectiveness of instructional material in achieving the cognitive learning outcomes when the learners have gained some experience or knowledge about the subject matter (36). Hence, in this study, the TBL method may be effective in promoting knowledge acquisition among junior students but became less effective for senior students.

With regards to the test scores, both practical sessions had significantly contributed to the improvement of the test scores, with the percentage of improvement being higher in the TBL compared to the control groups for both cohorts. Likewise, when compared between junior and senior students, the percentage of improvements were higher in the junior students in both practical sessions. One of the reasons that could have contributed to this result would be the effects of the structured guidance and reassurance of learning provided by the lecturers during the practical sessions, especially in the TBL practical. TBL contains some elements of inquiry-based learning (i.e., learning by understanding through critical thinking skills), which has been documented to benefit from various forms of learning guidance (37). However, these forms of guidance may lose their effectiveness when exposed to senior students, who are more mature as described by the aforementioned expertise reversal effect (36). Based on their previous learning experience, senior students might have encountered various ways to learn more efficiently. This condition is aligned with the guidance fading effect of the cognitive load theory that describes the need to reduce learning guidance when teaching the more experienced students (38).

In terms of the engagement score, it was revealed that only Year-2 students were significantly engaged in TBL activities. This finding is supported by a previous study that described active students' participation in a group discussion during a TBL session, which subsequently resulted in them to be actively engaged with the learning materials (16). In addition, another study had reported that the impact of TBL implementation on students' engagement had increased the students' enrolment in their learning session, evident by reduced dropout and increased participation rates (39). Moreover, the active learning strategy used in TBL was proven to enhance in-class engagement by promoting active interaction between learner-learner and learner-instructor towards the in-class activities (40). Nevertheless, the present study measured a specific type of engagement, which is cognitive engagement rather than physical engagement. Cognitive engagement could be defined as students' devotion to their mental and energy efforts to assimilate the intricate knowledge and acquirement of new skills throughout the learning process (41). It is well accepted that variations in cognitive engagement are correlated with the student's ability to self-regulate their learning and perceived ability to learn (42,43). In this study, the significantly higher cognitive engagement score of the TBL group among senior students reflects that they have higher self-efficacy for self-regulated learning compared to junior students, even though they were learning in a well-structured and controlled learning environment of TBL. This form of autonomous learning regulation might be more efficient among senior students who are more mature and have gained some learning experience before the current learning process. Having the ability to autonomously regulate their learning, the more experienced they would be to work independently with the groups in accomplishing the content of structured tasks, as well as having more freedom to explore ways in comprehending the open-ended task in TBL (44). This ability is expected to be underdeveloped among junior students who are less experienced compared to senior students.

Despite the aforementioned positive outcomes, there was insignificant difference in the internal motivation scores between TBL and control groups in both Year-1 and Year-2 cohorts. This finding contradicts the findings of several previous studies. One of the studies reported significant augmentation of students' motivation to learn in TBL environment compared to the conventional lecture method (45). Likewise, Jeno et al., (46) reported positive students' perception of the TBL approach, which managed to stimulate their interest to learn and eventually aroused their learning motivation. Another study conducted by Zareie et al., (47) also reported that TBL encouraged students to be fully prepared before the actual class; hence the students became more motivated to be involved in the subsequent active learning activities in the TBL session. It is postulated that the insignificant difference in the motivation score between TBL and control groups in this study could be due to the learners' unfamiliarity with the new learning strategy. Familiarity with an instruction and learning techniques is an important element that determines student's learning (48). Learners usually opt for a learning experience, in which they are familiar with the method that they perceived as relevant, practical, and applicable (49). Perhaps, the TBL approach could have been perceived as an unfamiliar learning method by the students as they had never been exposed to this method before this study. Hence, it could be argued that learning environments that support learners' choices and self-directness would determine the students' internal motivation level (50).

Nonetheless, the most important limitation of this study lies in the fact that the participants of this study were exposed to the TBL approach for a short duration of the intervention period. This single cycle of TBL exposure did not allow adequate exposure of the TBL approach to the students to develop a deeper impact on their learning experiences. Therefore, despite positive findings of the TBL application in this study, it is premature to conclude its impact on students learning unless these outcomes are measured longitudinally. It would be worthwhile to improve the applicability of TBL in future studies. Replicating the study for an extended period would be advantageous to evaluate the long-term impact of TBL on students' learning, particularly in the anatomy practical context. This study would provide more reliable data as the students will have more time to become familiarised with the activities conducted in the TBL approach.

CONCLUSION

This study provides a deeper insight into the possibility of incorporating TBL as one of the supplementary teaching methods in anatomy. The learning activities in TBL are highly structured and organized in such a way that they could facilitate active self-directed learning among students. As a teaching approach that focuses on prior preparation before class and application of knowledge during the class, TBL emerges as an alternative to overcome the declining conceptual knowledge among the medical students, particularly in gross anatomy teaching. This study contributes the evidence of the impact of TBL implementation in the reinforcement of students' learning performance, with regards to the students' acquisition of knowledge and higher cognitive engagement. However, it would be interesting to know how TBL would affect students' physical and emotional engagement in the learning process, which contributes to the acquisition of skills and other affective learning values. Hence, future studies should concentrate on exploring the impacts of TBL on other elements of learning before concluding it as an effective teaching method in gross anatomy practical.

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