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Assessment of first-year medical students' perceptions of teaching and learning through team-based learning sessions

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Obad AS, Peeran AA, Shareef MA, Alsheikh WJ, Kalagi DA, AlAmodi AA, Khan TA, Shaikh AA, Ganguly P, Yaqinuddin A. Assessment of first-year medical students' perceptions of teaching and learning through team-based learning sessions. *Adv Physiol Educ* 40: 536–542, 2016; doi:10.1152/advan.00001.2016.—Team-based learning (TBL) is an emerging teaching and learning strategy being employed in medical schools. The College of Medicine at Alfaisal University has adopted a TBL approach as an instructional method for first-year medical students. The aim of the present study was to describe the TBL method employed at Alfaisal University College of Medicine and to assess first-year medical students' perceptions of this learning modality for the anatomy- and physiology-based blocks/courses in organ systems form of curriculum. A five-point Likert scale questionnaire was structured based on Kirkpatrick's theory and assessed three major domains: reaction, learning, and behavior. Confirmatory factor analysis (CFA) and Cronbach's α-coefficient tests were used to assess the validity and reliability of the construct, respectively. CFA showed an adequate validity of the survey and Cronbach's α revealed an acceptable internal uniformity (0.69). A total of 185 respondents rated reaction, learning, and behavior toward introduction of TBL as 3.53 ± 1.01, 3.59 ± 1.12, and 3.57 ± 1.12, respectively. Excellent students rated TBL highly in all major domains compared with borderline students (reaction, behavior, and learning domains with P values of <0.049, <0.035, and <0.031, respectively). Students who had prior teamwork experience rated TBL higher in terms of their learning experience compared with those who were rarely involved in team work. This study demonstrated that Alfaisal University first-year medical students perceived TBL positively as a teaching and learning strategy for functional anatomy, and prior involvement in teamwork and academic performance correlates with higher ratings of TBL.

team-based learning; functional anatomy; medical education; problem-based learning; self-rating

WITH INCREASING NUMBERS OF MEDICAL STUDENTS, there is an increasing need for resources, faculty, and lecture halls. Current trends in medical education aim to solve this issue, along with providing teaching strategies that are student-centered and promote active learning (8–10, 32). Moreover, these strategies are also meant to enhance learning in context and problem solving/clinical application skills (8, 10, 32). One of the recent methods introduced by medical educationists around the world with the above-mentioned attributes has been "team-based learning" (TBL).

Larry Michaelson was the first to introduce TBL as an educational modality at a business school in 1970 (20, 23). This approach has also been successfully adopted by a number of medical educators (29). The reason for this frequent adoption of TBL as a teaching and learning method is to enhance active learning, problem-solving skills, and teamwork among medical students (13). TBL is an active learning strategy that provides students with the opportunity to apply conceptual knowledge through discussions within small groups (20). In its conventional format, TBL consists of three successive phases: *1*) individualized active learning of preassigned faculty-derived learning objectives, *2*) demonstration of acquired knowledge through individual readiness assurance testing (iRAT) and team readiness assurance testing (tRAT), and *3*) application of concepts in solving problems (11, 22).

Teaching methods like problem-based learning (PBL) share similar characteristics with TBL, including being conducted in small groups and promoting both active learning and problem-solving skills (22). However, TBL's uniqueness is that it is substantially less intensive in terms of faculty resource and infrastructure (14, 15). It is usually conducted in large group settings (1 large classroom) where the students are divided into multiple small groups (15). In addition, a TBL session of more than 100 students can be conducted by a single instructor (15).

In the Kingdom of Saudi Arabia, many medical schools continue to shift toward implementing integrated medical curricula, using PBL as the essential modality of teaching (3). Likewise, Alfaisal University College of Medicine (a 6-yr-old private, nonprofit institute) has been using PBL as the prime instructional method (5). However, in the academic year of 2013–2014, the Curriculum Committee of the university decided to introduce TBL as a core instructional strategy in the first year of the medical school to address two main issues. First, it was found that freshmen (high school graduates) with little or no previous experience in teamwork and problem solving found it difficult to adapt to an intensive active learning strategy like PBL, resulting in gaps of knowledge and skills. Second, as the class size increased to ~200 students, it became difficult for college administrators to deal with the increase in demand for faculty and infrastructure resources required to conduct PBLs effectively. However, abiding by the Royal decree of segregation between sexes in education and cultural

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peculiarities of the region, a concern about implementing TBL was raised in such circumstances.

Many reports have shown that TBL is an effective teaching and learning method (24, 27, 31) This study describes the first-year medical students' perceptions of TBL as an educational tool. The objectives of the present study were to *1*) assess the perception of first-year medical students toward the application of TBL at Alfaisal University, College of Medicine, *2*) identify key issues that might influence medical students' abilities to learn via the TBL approach, and *3*) examine the applicability of TBL while preserving the cultural peculiarities of the region.

METHODS

Alfaisal University College of Medicine, founded in 2008, is a private college that has adopted an integrated curriculum. The medical curriculum at the college consists of three successive phases. *Phase 1* (*years 1* and *2*) consists of organ system-based courses/blocks with a primary emphasis on the structure (anatomy) and function (physiology) relationship. *Phase 2* (*year 3*) consists of organ system-based courses with the core emphasis on pathophysiology of disease. *Phase 3* (*years 4* and *5*) consists of the clerkship years. Anatomy and physiology are taught in all three phases of the curriculum and integrated with function, abnormality, and clinical application as students progress from phase to phase. Since 2013, structure (Anatomy) and function (Physiology) in *year 1* are taught mainly through TBL sessions, practical sessions, and didactic lectures. TBL sessions are held for 2 h every week throughout the entire extent of *year 1*, which includes seven organ system-based (structure and function) blocks/courses.

In organizing these TBL sessions, approximately 200 first-year medical students were divided into 16 different groups. Based on the regulations of the Ministry of Higher Education in the Kingdom of Saudi Arabia and cultural sensitivities, these groups were separated into eight male and eight female groups. In 2014, we reduced the group size from 10 to 12 to five to seven students in each team. Accordingly, we divided the class into 15 male and 15 female groups. Since these were first-year medical students we do not have their previous record of performance in group work; therefore, distribution was performed by instructors using the alphabetical stratification system.

The typical TBL session conducted at Alfaisal University College of Medicine is composed of three phases: preclass preparation, readiness assurance tests, and application of course concepts. In the first phase, students are expected to prepare for the TBL sessions ahead of time to maximize their learning outcomes. One week before the TBL session, faculty-generated objectives are posted onto the learning management software Moodle (version 2.8, Moodle Pty, Perth, Australia), which is accessible to students and faculty. The students are also provided with learning resources, including recommended text books, prosected specimens in the laboratory, videos, and access to the image bank. This is followed by *phase 2*, the readiness assurance test, which is divided into two separate stages; iRAT (individual readiness assurance test) and tRAT (team readiness assurance test). The cumulative scores for both iRATs (70% weight) and tRATs (30% weight) constitute 15% of the overall grade of the respective block/course. The weight of iRAT is deliberately kept on the higher side to provide incentive and ensure active learning among students. However, in subsequent years, as the clinical application part is added the weight of three components is modified to iRAT (50%), tRAT (30%) and clinical application (20%). During readiness assurance testing, students use an audience response system from Turning Technologies to answer questions presented on the screen. Use of this audience response system (clickers) has helped to generate immediate feedback for both iRAT and tRAT performances. Subsequently, this has enriched discussion between relevant subject specialists and participating students. However, we are in the process of developing an electronic immediate feedback system for tRAT similar to scratch card-based IF/AT (immediate feedback assessment test). During the iRAT stage of TBL, students are seated in an exam-like fashion. Students are given 10 multiple-choice questions and 60 s to answer each question. At the end of the iRAT session, students are rearranged into their respective groups. Clickers are collected from the students; each group is left with one clicker for the tRAT. During tRAT, students are provided the same set of questions presented during iRAT. A 90-s time frame is given to the teams to answer each question. Students discuss each question within their teams before answering via the clickers. Team answers are further discussed with the guidance of the subject specialist. The final stage of the TBL session involves the application of objectives with clinical scenarios. In this stage, students are presented with real-life clinical situations where they can apply their knowledge and critical thinking to solve clinical problems. Examples of RAT questions and clinical application scenarios are given as Figs. 1 and 2.

Questionnaire development and distribution. A three-level modified model of the Kirkpatrick's learning and training evaluation theory was used to construct the questionnaire (34). The model evaluates three levels of educational evidence: reaction, learning, and behavior. Accordingly, an anonymous, self-administered, categorical questionnaire was developed. The questionnaire consisted of demographic questions, 14 Likert scale-based quantitative questions, and three qualitative open-ended questions. Demographic questions addressed students' ages, sexes, academic performance levels, and institutional backgrounds. Quantitative questions were scaled from 1 to 5 depending on level of agreement (with 1 corresponding to least agreement and 5 relating to highest agreement). Among quantitative questions, those pertaining to reaction recorded students' satisfaction with the TBL experience, whereas those regarding learning aspects noted the increment of knowledge as a consequence of the TBL approach. The behavior section assessed behavioral adjustments, including students' team work skills, studying techniques, and self-evaluation. Qualitative assessment was completed using three open-ended questions at the end of the questionnaire; such questions accommodated any additional opinions or suggestions from the students.

After ethics approval from the Ethical Review Committee of Alfaisal University was attained, the questionnaire was piloted on seven students to assess its language simplicity, clarity, and readability, based on which minor changes were made to the questionnaire. Then, with the help of the Department of Anatomy and TBL, group leaders' students were surveyed using the paper-based questionnaire at the end of the last TBL session of the sixth block of the first year. Furthermore, to abide by ethical principles the survey was anonymous, and students were asked to voluntarily report their demographic information and self-identify their academic performance level.

Statistical analysis. IBM SPSS version 20 statistical software (IBM, Armonk, NY) was used to examine the relationship between the different components of the questionnaire with respect to demographic information. Whereas Wilcoxon and Mann-Whitney *U*-test was performed to determine whether there were any differences between male and female students in rating the three domains of the questionnaire, one-way analysis of variance (ANOVA) was used to determine whether students with different academic levels or previous involvement in teamwork showed any difference in self-ratings of the three major domains. ANOVA test was followed by Bonferroni Post Hoc Multiple Comparisons for Observed Means test to identify the exact significant difference between the groups. All the mean values are represented as means ± SD.

One-way ANOVA test was applied to analyze statistically significant differences between mean scores of the final summative examination of students who took these courses in 2012 (pre-TBL period) as well as in 2013 and 2014 (after TBL implementation).

- The resting membrane potential of a cell results from the fact that there is an unequal distribution of charged ions across the membrane. Which of the following is most important in maintaining this unequal distribution?

A. High extracellular concentration of sodium
B. High intracellular concentration of potassium
C. Presence of non-diffusible negatively charged molecules inside the cell
D. The electrogenic property of the Na^+/K^+ ATPase
E. The membrane is more permeable to certain ions than others

- You discover a neurotransmitter. You demonstrate that it acts by activating a metabotropic receptor leading to opening of a K+ channel. What type of post synaptic potential would you predict in the target cell?

A. Fast excitatory post synaptic potentials
B. Fast inhibitory post synaptic potentials
C. Fast miniature end-plate potentials
D. Slow excitatory post synaptic potentials
E. Slow inhibitory post synaptic potentials

- Twenty-two year old Zafar received multiple stab wounds in the back while resisting an attempted robbery. An MRI done the next day showed hemi-section of the spinal cord at the level of the left T7 vertebra. Which one of the following spinal segments corresponds to T7 vertebral level?

A. L1
B. T10
C. T11
D. T8
E. T9

Fig. 1. Illustration of sample readiness assurance testing (RAT) questions from Neuroscience Module.

In the final part, open-ended questions were analyzed using directed content analysis. The main themes for the analysis were structured based on the subthemes of the three domains. Similar domains were then merged together (12).

RESULTS

Demographic characteristics of study population. Excluding students who were absent, all first-year medical students participated in the study. Hence, 94 (50.8%) male and 91 (49.2%) female students participated in the study. Table 1 illustrates demographic information of the participants.

The validity and reliability of the questionnaire. The Kaiser-Meyer-Olkin Measure of Sampling Adequacy test value was calculated at 0.87, and Barlett's Test of Sphericity (28) was significant with ($\chi^2 = 891.42$, degree of freedom = 91) P value of <0.001. Based on these results, the data were suitable for confirmatory factor analysis. Consequently, confirmatory factor analysis was performed using AMOS statistical software to assess the validity of the questionnaire (26). The confirmatory factor analysis provided an acceptable fit to an a priori three-factor model when two matching content item pairs were allowed to be correlated ($\chi^2 = 131.23$, root mean square error of approximation = 0.07, non-normed fit index = 0.89, comparative fit index = 0.92, and goodness-of-fit index = 0.91). All the item loadings of the questionnaire were >0.38, so the results suggested adequate construct validity (6a). Reliability wise, the Cronbach's α-coefficient of each domain was 0.70 for reaction, 0.63 for learning, and 0.74 for behavior. The mean Cronbach's α-coefficient was 0.69 which was indicative of an acceptable internal consistency.

On a rainy day 20 year old Abdullah Haider slipped from the roof top of his house, injuring his neck. He was rushed to a hospital where the physician noted that he was unable to move right side of his body. He had a heart rate of 88/min and a blood pressure of 110/75 mm of Hg. Initial neurological examination showed depressed motor and sensory function in both upper and limbs. The anal reflex was also absent. After 24 hours, neurological examination showed a flaccid and weak right side of the body and loss of position and vibratory sensations below the level of C5 on the right side. There was also left-sided loss of pain, temperature and crude touch below the level of C5 and a complete loss of sensation in C5 dermatome on the left side. On CT scan, a piece of fractured vertebra was found impacted in the spinal cord at C5 level on the right side. The patient was then operated upon to remove the bone fragment and repair the damaged vertebra. After 1 month on subsequent clinic visit, a comprehensive neurological examination revealed the same deficits except for increased tone in all muscles on the right side of the body. The abdominal and deep tendon reflexes were exaggerated on the right side.

- Questions:

Q1. Give reason for depressed motor and sensory function in both upper and lower limbs and absent anal reflex
Ans: Spinal shock.

Q2. Name the tract which is responsible for conducting position and vibratory sensation
Ans: Dorsal column tract (Fasciculus gracillis and cuneatus)

Q3. Explain why pain and temperature sensations are lost on left side below C5 while position and vibratory sense are lost on the right side in this case?
Ans: This is because Spinothalamic pathways (pain and temperature tracts) cross at spinal cord level while dorsal column tracts remain uncrossed at the level of spinal cord.

Q4. Why did he develop exaggerated deep tendon reflexes on right side?
Ans: Damage to Right Corticospinal tract (Upper Motor Neuron)

Fig. 2. Illustration of sample clinical application questions from Neuroscience Module.

Table 1. *Demographic data of the participants as obtained via the questionnaire*

Variables	*n* (%)
Sex (n = 185)	
Male	94 (50.8%)
Female	91 (49.2%)
Age (n = 175)	19.29 ± 1.16*
Academic performance (n = 179)	
Excellent	60 (34%)
Average	103 (58%)
Pass (borderline)	14 (8%)
Fail	2 (1%)
Institutional background of freshmen (n = 180)	
International school	45 (25%)
Private school	32 (18%)
Saudi governmental school	25 (14%)
Alfaisal University preparatory year	66 (37%)
Another university	12 (7%)
Previous involvement in teamwork (n = 166)	
A lot	42 (25%)
Often	97 (58%)
Rare	27 (16%)

*Means ± SD.

Students' perception of TBL as an instructional method. The reaction to the introduction of TBL as an educational method was satisfactory, with the average self-rating being (3.53 ± 1.01) in the reaction domain (Fig. 3). The students emphasized the value of a subject specialist in guiding students during TBL by giving it the highest average score (3.97 ± 0.85). The lowest average score was given to the extent to which they enjoyed the TBL experience (3.23 ± 1.09) (Fig. 3).

The overall perception of students regarding their learning via TBL was (3.59 ± 1.12; Fig. 4). They ranked immediate correction of mistakes and concepts as the greatest advantage of TBL (3.99 ± 0.95); however, interestingly, they ranked the use of clickers low in providing this immediate feedback (2.96 ± 1.36) (Fig. 4).

Finally, overall perception of students regarding changes in their behavior with respect to introduction of TBL was satisfactory (3.57 ± 1.12). The students perceived that with introduction of TBL their self-evaluation process had improved (3.72 ± 1.09); however, they did not feel that TBL had a greater impact on improving their communication skills (3.37 ± 1.09) (Fig. 5).

Sex-based differences in reaction, learning, and behavior in TBL. There was no significant difference in perception between male and female students in terms of reaction (P = 0.65), learning (P = 0.80), or behavior (P = 0.90).

Differences based on academic level in reaction, learning, and behavior in TBL. Students' perceptions of their academic level played a significant role in their self-evaluation of reaction ($P < 0.01$), learning ($P < 0.01$), and behavior ($P < 0.001$) in TBL settings. Excellent students perceived introduction of TBL as a fulfilling educational experience with a higher score in the reaction domain (3.67 ± 0.46) compared with borderline students (3.27 ± 1.27) ($P < 0.049$). Furthermore, excellent students perceived the introduction of TBL as advantageous to their learning process and rated it higher (3.78 ± 0.54) than students with average academic levels (3.51 ± 0.61) ($P < 0.035$). Finally, excellent students perceived improvement in

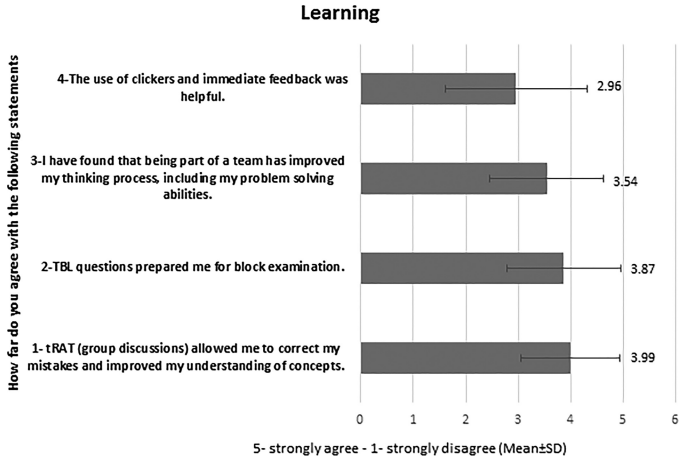

Fig. 4. Illustration of the responses of the students on the learning domain of the TBL questionnaire. Mean scores and standard deviation of the responses made by the students on each question of this domain are also given. tRAT, team readiness assurance testing.

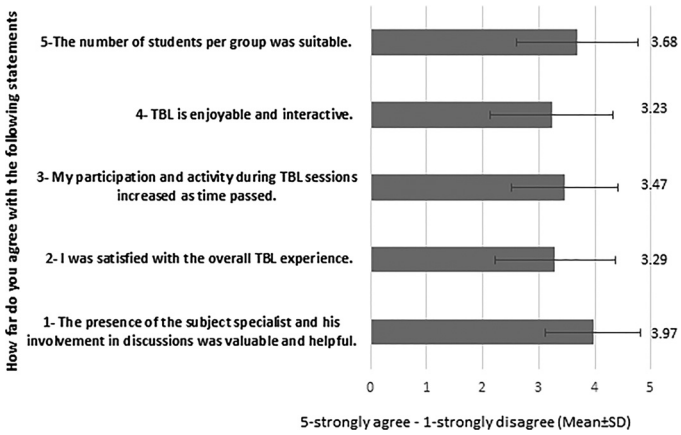

Fig. 3. Illustration of the responses of the students on the reaction domain of the team-based learning (TBL) questionnaire. Mean scores and standard deviation of the responses made by the students on each question of this domain are also given.

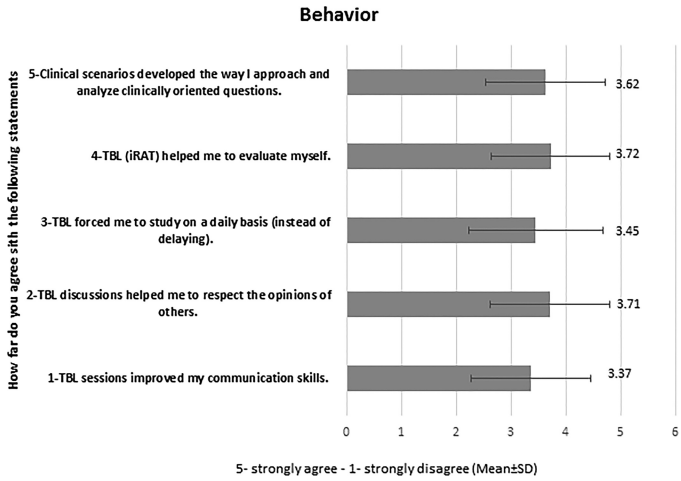

Fig. 5. Illustration of the responses of the students on the behavior domain of the TBL questionnaireMean scores and standard deviation of the responses made by the students on each question of this domain are also given. iRAT, individual readiness assurance testing.

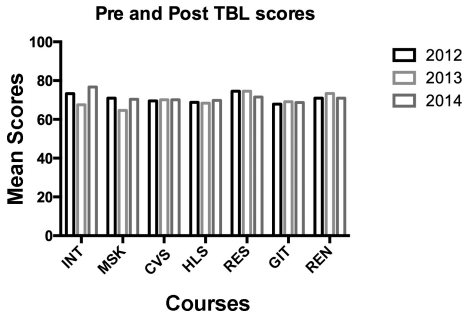

Fig. 6. Bar graph showing mean scores of the final summative block examinations before and after implementation of the TBL. INT, introductory course; MSK, musculoskeletal course; CVS, cadiovascular; HLS, hematopoietic and lymphatic system; RES, respiratory; GIT, gastrointestinal; REN, renal.

their behavior-related skills with the introduction of TBL (3.80 ± 0.46) higher than when compared with average students (3.45 ± 0.51) ($P < 0.001$).

Impact of previous team work experience on students' perception regarding TBL. Students' involvement in previous teamwork significantly affected their gains in learning ($P < 0.01$) and behavior ($P < 0.047$) domains. Analysis revealed that students with previous teamwork experience perceived the introduction of TBL as an enhancement of their learning capabilities (3.70 ± 0.39) when compared with those with rare involvement (3.39 ± 0.57) ($P < 0.01$).

Analysis of students' mean scores on the final summative block examinations. No statistically significant difference was found between the mean scores of the final block examinations before and after the implementation of the TBL (Fig. 6).

Analysis of qualitative responses regarding TBL. As for the qualitative analysis, it revealed three themes regarding TBL: *1*) it is an effective tool for learning concepts and correcting misunderstandings, *2*) it offers a unique self-assessment approach by providing students with the opportunity to study on a daily basis, and *3*) it enables integration of theory with clinical application. Table 2 outlines percentage of these aforementioned themes and consequently generated representative quotes.

DISCUSSION

There is a paradigm shift in the mode of education delivery in medical schools around the world (17). Two notable learning pedagogies that have been widely incorporated are PBL and TBL (1). PBL has been reported to have beneficial outcomes on students' skills and competencies (18). Similarly, TBL, with its close structural resemblance to PBL, has been embraced recently in medical schools (7, 16). TBL is also designed to hone students' clinical reasoning and communication skills but in a larger lecture hall with lower faculty/student ratios compared with PBL (7, 16). Several reports state that introducing TBL to medical students in foundation years would help prepare students effectively for future beneficial PBL experience (1). This study describes first-year medical students' perceptions regarding the introduction of TBL as an educational strategy to teach functional anatomy at Alfaisal University, College of Medicine. The results demonstrate that the students perceived TBL to be a satisfactory teaching and learning modality, which is consistent with a recent systematic review of several reports published on TBL (27).

We believe that both pedagogies, TBL and PBL, are needed to promote an effective learning environment for medical students. However, whether TBL precedes PBL or both methods are introduced simultaneously merits further investigation.

This study showed that students perceived the availability of subject specialists during TBL sessions as an enriching educational experience. This observation has been noted in other studies, which demonstrated that students prefer the systematic guided discovery approach to learning in which the facilitator plays a crucial role in the organization of the discussions (1). This may also be true, as many of our freshmen are high school graduates with little or no prior experience of active learning and teamwork. In this study, these findings were strengthened further by students' perception that TBL contributes remarkably in correcting mistakes and wrong concepts. In addition, it helps students in terms of preparation for examinations and assessments. Many objective studies have shown that the students studying via TBL method performed better on examinations and assessments compared with students studying through traditional educational strategies (24, 25, 31).

Participants in our study perceived opportunity to self-evaluate during a TBL session as one of the key advantages of the TBL. Immediate feedback during TBL allows students to identify their weaknesses and correct them. However, students rated the use of an audience response system (ARS) to provide immediate feedback low. We think that this low rating can be attributed to the fact that the clicker-based system employed at our institute is a new modality through which students possess only one chance to choose the correct answer. Thus, anxiety and stress associated with the use of this new technology and

Table 2. *Qualitative data from direct content analysis*

Theme	Percentage	Representative Quotes
TBL group discussion as a means to understand concepts and correct mistakes	30.8% ($n = 57$)	"The group discussion is a nice way of learning new stuff." "It enhances my group learning skills." "It helps me clear up misconceptions." "We have the chance to know and discuss the wrong and correct answers."
TBL as a means for students to study on daily basis	25.4% ($n = 47$)	"I can evaluate myself during the block instead of waiting until the end of the block." "This is the only reason I study during the week." "The comparison made between my TBL and exam scores provided me with a more in-depth knowledge of where I stood and what I need to work on."
Advantage of TBL in preparing students for clinically oriented exam questions	24.8% ($n = 47$)	"This gives us an idea about examinations and how to prepare for them." "These kinds of questions are beneficial and help in preparing for the final." "It helps me with clinical thinking (clinical scenario)."

TBL, team-based learning.

fears of losing marks might have contributed to this perception. Previous studies have also showed that although students appreciate immediate feedback received through ARS, they still rate its use in TBL low (6). This low rating of ARS is associated with fear for technology failures and immediate scoring of user-based errors while making responses (21).

A previous study assessing students' perception of TBL demonstrated that academic levels of students are well correlated with their self-rating of TBL as an educational strategy. In fact, honor students perceived TBL as a better learning modality than students who were either borderline or failed on a regular basis (11). Moreover, a lower rating of TBL by underachieving students could be attributed to their difficulty in assessing their perceived learning needs in a new learning environment such as TBL (30). Our findings are consistent with these studies; interestingly, our study also showed for the first time that previous involvement in group work improves students' attitudes toward TBL.

Our findings do not demonstrate any significant differences in perception between male and female students toward TBL sessions. This finding is interesting considering the fact that the TBL sessions offered at our institute were organized separately for male and female students. Thus, this indicates that there was no significant difference in the educational experience of either sex, even though it was administered to them in a segregated setting. Interestingly, a study from Oman, which has similar cultural sensitivities, reported dissatisfaction of female students with the implementing of TBL in mixed-sex settings (20a). Yet another study from the same region reported positive experiences among both sexes when cultural norms were observed (15). Therefore, we believe that the implementation of TBL in segregated settings will not have an effect on its educational value.

Our study did not show any significant increase between mean scores of students on the final summative block examinations before and after the implementation of TBL. Many previous studies have showed no difference in exam scores of TBL vs. other small-group learning cohorts (4, 19, 24, 33). In our case, there are several issues that to be considered: *1*) two different sets of students were compared with different academic backgrounds and skills; *2*) they were given two different types of summative assessments that may have varied on the basis of difficulty; and *3*) the previous group of students used PBL as a small-group strategy instead of TBL. For these reasons, we believe that unless we control for all of above-mentioned factors, we cannot assess the effect of TBL on the performance of students on the summative examinations.

Teaching and learning anatomy has been a subject of discussion and development for a long time. Various modalities and approaches have been used for the dissemination of anatomical sciences in past years, including dissections, TBLs, PBLs, and image-based technology. Previous studies indicated that student perception while adapting to newer methodologies is crucial (2). This helps educators to identify deficiencies and help to improve the educational process (2).

CONCLUSIONS

Based on perceptions of the first-year medical students involved in the study, implementation of TBL in our institution has resulted in positive outcomes in the three assessed domains (reaction, learning, and behavior), regardless of the special circumstances of sex segregation. Students' academic performance and previous group work experience correlates well with students' perceptions toward TBL. We continue to modify the TBL process based on students' evaluations and feedback. In the future, it would be interesting to evaluate the effect of TBL on preparing students for future PBL experience. This study reinforced and improved the existing evidence about TBL implementation in the Middle Eastern region. Considering the ethnic diversity of Alfaisal University, results of this study reflect students' perception of TBL in the Arabian Peninsula. In addition, this study described the TBL experience in unique educational settings where *1*) the study population was recently graduated high school students and *2*) male and female students were learning through this pedagogical method in segregated settings.

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DISCLOSURES

No conflicts of interest, financial or otherwise, are declared by the authors.

AUTHOR CONTRIBUTIONS

A.S.O., D.A.K., A.A.A., T.A.K., and P.K.G. conception and design of research; A.S.O., W.J.A., D.A.K., A.A.A., and A.A.S. performed experiments; A.S.O., A.A.P., W.J.A., D.A.K., A.A.A., T.A.K., A.A.S., P.K.G., and A.Y. drafted manuscript; A.A.P., M.A.S., and A.Y. interpreted results of experiments; A.A.P. and W.J.A. prepared figures; M.A.S. analyzed data; A.A.S., P.K.G., and A.Y. edited and revised manuscript; P.K.G. and A.Y. approved final version of manuscript.

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