

Team-based learning as an inspiring tool for teaching Parasitology in the integrated curricula

Original
Article

Ayman M El-Ashkar^{1,2}, Adel M Aboregela², Yosra H Alam-Eldin¹, Ashraf S Metwally³

Departments of Medical Parasitology¹, and Basic Medical Sciences², Faculty of Medicine^{1,2,3}, and Collage of Medicine², Ain Shams^{1,2}, Zagazig³ and Bisha² Universities, Cairo¹ and Zagazig³, Egypt, Bisha, KSA²

ABSTRACT

Background: Most medical colleges all over the world shifted to programs adopting integrated student-centered curricula. Team-based learning (TBL) is a novel learning tool to benefit from self-directed learning at home and team learning in class.

Objective: To evaluate the effectiveness and students' perceptions of TBL for learning Medical Parasitology.

Subjects and Methods: This study addressed 2nd year medical students attending Phase I of Medical program at the College of Medicine, University of Bisha (UBCOM), Saudi Arabia in two batches; batch (2020-2021, n=80) studied 3 topics in Medical Parasitology employing traditional lectures (TL), and batch (2021-2022, n=81) studied the same topics illustrated by the same tutor employing TBL. The study compared between marks of students (2021-2022) achieved in the individual readiness assurance test (iRAT) and the team readiness assurance test (tRAT) through the TBL activities using seven multiple choice questions (MCQs). It also compared students' marks of the 2 batches in the selected repeated 12 MCQs in the final course exam. A survey was designed to measure students' perceptions toward TBL as an educational strategy in Medical Parasitology.

Results: Regarding students' achievement, there was a significant increase ($P<0.001$) in the mean \pm SD of marks in tRAT compared to iRAT for TBL learned students. Moreover, there was a significant increase ($P<0.001$) in the final course marks for questions touching the Parasitology topics among students of batch (2021-2022) compared to batch (2020-2021). Regarding students' perception of TBL, students agreed that pre-class study enabled them to answer the iRAT well with effective group discussion during tRAT (60%, and 66.6%, respectively). The TBL activity was reported as an effective tool that supports understanding of Parasitology topics (85%), communication skills (68.4%), dealing with innovative learning technology (58.4%), the learning competencies of medical students (53.3%), learning Parasitology curricula (56.7%), and engagement throughout the activity time (60%). Shortage of pre-class time (28.3%), the difficult language of the reference textbook (28.3%), the stress of assessment (23.4%), and activities carried out during TBL conduction, especially tRAT (20%) were the main challenges.

Conclusion: Group learning is more beneficial than individual learning since it is a more effective tool for learning than traditional lectures although it has several challenges.

Keywords: Assurance; integrated curriculum; medical parasitology; pedagogic education; readiness; team-based learning.

Received: 10 February, 2023; **Accepted:** 15 April, 2023.

Corresponding Author: Ayman M. El-Ashkar, **Tel.:** +20 1030876995; +966 502341013, **E-mail:** aymanpara@yahoo.com

Print ISSN: 1687-7942, **Online ISSN:** 2090-2646, **Vol. 16, No. 1, April, 2023.**

Abbreviations: **AEs:** Application exercises; **CBL:** Case based learning; **IFAT:** Immediate feedback assessment technique; **iRAT:** Individual readiness assurance test; **MCQs:** Multiple-choice questions; **PBL:** Problem based learning; **SDL:** Self-directed learning; **TBL:** Team based learning; **tRAT:** Team readiness assurance test

INTRODUCTION

In fact, TBL supports the flipped classroom model of healthcare education by offering a novel efficient approach to student-centered learning^[1]. It is a form of small-group instruction that encourages students to apply conceptual knowledge through a recurrent series of tasks that require individual work, group work, and immediate feedback^[2,3]. In contrast to other small group methods (e.g. problem-based learning), a single subject matter expert can supervise numerous student small groups operating inside a big lecture

hall^[4]. The in-class TBL exercises provide an engaging, expert-led learning experience that enables a large number of students to collaborate in small teams to apply content to a particular problem^[5].

It is worth noting that TBL is carried out in three stages. In Phase I, pre-class preparation gives students a basic knowledge and grasp of the subject matter to enable them to fully participate in class activities. In Phase II (readiness assurance phase), the

iRAT normally consisting of 10 to 20 MCQs, is designed to encourage students to accomplish the pre-class reading. Peer teaching is used in the tRAT to strengthen comprehension and clarify concepts. A scratch-off card (immediate feedback assessment technique or IFAT card) is used to score the tRAT. Each team replies to tRAT items by scratching off their chosen response to uncover a star if they have answered properly. The IFAT cards function similarly to lottery tickets. If an inaccurate answer is selected, the group continues to cross off their second choice. This process is repeated until the right answer is achieved. Depending on how many tries are required to get the question right, full or partial credit (4 points, 2 points, 1 point, or 0 points) is given. The tutor has the chance to clarify any topics that are still confusing to a significant number of students through a moderated class discussion or brief lecture according to readiness assurance and feedback processes. The most crucial stage of TBL is in Phase III, where students are given higher-order application exercises (AEs). Typically, teams have to reach decisions in these situations by employing course concepts to solve AEs. The "4S" principle, significant problem, same problem at a specific moment, specific decision, and simultaneous report should be used to arrange the application problems. Notably, AEs are designed to help students learn Bloom's taxonomy at higher levels^[4,6-8]. The latter is a scale to evaluate the level of students' learning where "remembering of knowledge" is at the base, and "create novel ideas" is at the top of the pyramid (Figure 1). The graded components of TBL include opportunities for student appeals for another learning opportunity. Only when a group feels there is a better solution that requires references and a justification or when the question is unclear and necessitates students to clarify and recreate the question are appeals permitted^[6].

To achieve standardized TBL approach, the following issues should be fulfilled:

1. Team formation and dynamics: Carefully established and managed teams, in which students should be assigned to teams using a transparent

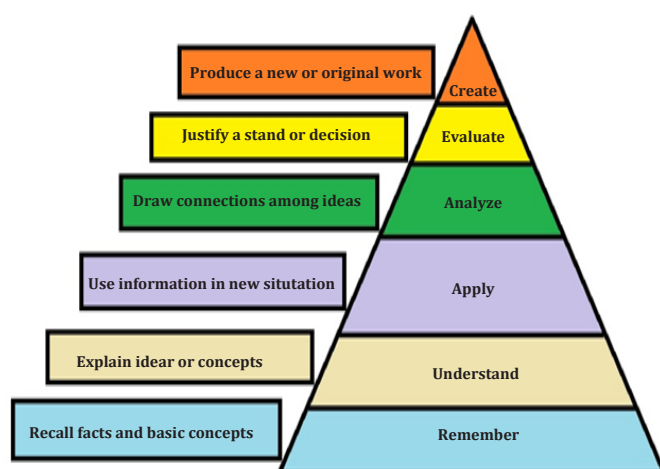


Fig. 1: Bloom's taxonomy^[8].

procedure to guarantee there are no pre-existing friendship groups-based teams and to ensure each team has a varied mix of students. Four main components were known for TBL, i.e., background knowledge, gender mix, education, and training^[9]. In order to improve team dynamics, trust, and diversity of resources within the group, continuity of learning, and team cohesion, guidelines advise student teams to "remain together for as long as possible"^[3]. Orientation of students for TBL activity was done in the 1st course conducted in the 2nd year named "Introduction to Medicine and Medical Education". In this course, the students received complete illustrations about TBL, problem-based learning (PBL), seminar, case-based learning (CBL), skill lab and simulations, medical professionalism, E-learning, mentoring, and communication skills. In our college, TBL is conducted on a weekly basis by a subject expert in different courses starting from year 2. The college registrar develops the student teams for each batch based on their academic achievements in the 1st year in order to ensure diversity of academic performance in each team".

2. Immediate feedback and frequent assessment:

When responses are addressed right away after the tRAT is finished, with explanation from the facilitators, students receive frequent and rapid feedback through the iRAT and tRAT processes. The TBL approach is built around providing students with instant feedback so they may gauge their degree of topic knowledge. By challenging students with follow-up questions rather than by lecturing, facilitators find gaps in students' understanding and promote critical thinking. Feedback is a key component of TBL activity that enhances knowledge acquisition, retention, and group learning^[10,11].

3. Challenge utilizing AEs: Teams are challenged to employ their aggregate knowledge, clinical reasoning, ethical perspectives, skills, and values to solve challenging clinical problems that relate to real-world scenarios during the clinical problem-solving exercises^[12,13].

4. Evaluation: Student peer evaluation is a part of the TBL peer evaluation process in which students contribute to the grades of other team colleagues by giving their particular team members both quantitative and qualitative input^[2,3,10,12]. For determination of student achievement in similar studies, iRAT, tRAT, application exercise, and peer review account for 20%, 35%, 35%, and 10%, respectively^[2].

Curriculum in University of Bisha-College of Medicine (UBCOM): After examining several curricula from medical schools in the Kingdom of Saudi Arabia and other international medical schools across the world, UBCOM employs an integrated, student-centered educational approach. The curriculum committee has adopted the SPICES (S: Student centered, P: Problem based, I: Integrated, C: Community based, E: Elective,

S: Systematic) model of instruction. The five-year integrated curriculum at UBCOM is divided into three phases: core medical sciences in Phase I, pre-clerkship in Phase II, and clerkship in Phase III. These phases that begin after the first year provide students with the important basic science principles that serve as the cornerstone of further undergraduate medical education. The three phases' courses are delivered in modules with varying lengths, ranging from two to ten weeks at most.

Phase I, the first round of the curriculum, is an introduction to the fundamentals of medical sciences and imparts fundamental knowledge about the structure and function of the human body. Eight successive modules are used to teach these academic sciences 1) Introduction to medicine and medical education, 2) Structure and function, 3) Behavioral science and doctoring, 4) Biochemical and genetic basis of human body, 5) Man and his environment, 6) Nutrition and metabolism, 7) Growth, development, and aging, and 8) Principles of diseases.

Phase II helps them integrate the knowledge they gained during Phase I. Eight body organ/system modules are included in Phase II, in addition to six other modules, including 1) Basic epidemiology, 2) Scientific research, 3) Clinical Pharmacology, 4) Public Health, 5) Non-communicable diseases, and 6) Clinical skills.

Phase III clerkship enables the students to apply medical knowledge and skills through clinical courses that include bed-side teaching activities including Family Medicine, Radiology and Imaging, Psychiatry, Pediatrics, Otorhinolaryngology, Medical Professionalism, Obstetrics and Gynecology, General Surgery, Orthopedics, Ophthalmology, Dermatology, Internal Medicine, Forensic Medicine, and Emergency Medicine.

It is worth mentioning that several teaching and learning tools were adopted in UBCOM such as PBL, interactive lectures, TBL, integrated seminars, case-based learning (CBL), self-directed learning, hospital and community field visits, practical and clinical skill activities^[14].

Parasitology teaching in UBCOM: This starts in Phase I during two modules (Principles of Diseases, and Hematopoietic System and Host Defense) in which Medical Parasitology' basics are conducted. It continues in Phase II during three modules (GIT, Respiratory System, and Cardiovascular System), and in Phase III in two modules (General Surgery, and Dermatology).

Keeping this layout into consideration, our study aimed to evaluate the effectiveness of TBL in Medical Parasitology course with monitoring of the students' perception of TBL approach.

SUBJECTS AND METHODS

This analytical cross-sectional study was conducted in Medical Microbiology Unit, College of Medicine, University of Bisha, KSA during the period from March, 2021 to April, 2022.

Study design: A mixed explanatory quantitative and qualitative cross-sectional study was carried out to evaluate the efficiency of TBL approach. Assessment parameters included students' performance, students' marks, and measuring the strength of the relationship between iRAT and tRAT of the TBL in the same academic year, as well as between the achievements in the two successive academic years. Students' performance was assessed by twelve MCQs selected from the final examination in the two successive academic years (2020-2021, and 2021-2022). The MCQs were specific for Medical Parasitology objectives delivered as traditional lectures in one group (2020-2021) and as TBL in the other group (2021-2022). Marks of batch 2021-2022 students achieved in iRAT and tRAT through the TBL activities using seven MCQs were compared. The study also compared students' marks in the selected repeated twelve MCQs.

Study target population: Participants included the second-year students from the College of Medicine, University of Bisha in the academic years 2020-2021 (n = 80) and 2021-2022 (n = 81) who were registered in the integrated course "Principles of Diseases".

The TBL activity: The study included three TBL activities in Medical Parasitology topics (Table 1). Orientation of students for TBL activity was performed in the 1st course conducted in the 2nd year (Introduction to Medicine and Medical Education). The students received comprehensive illustrations regarding TBL, PBL, seminar, CBL, skill lab. and simulations, medical professionalism, E-learning, mentoring, and communication skills. In our college, TBL is conducted on a weekly basis by a subject expert in different courses starting from the 2nd year. The college registrar develops the student teams for each batch based on their academic achievements in the 1st year in order to ensure diversity of academic performance in each team.

The topics of this study are included in the approved course specification for Principles of Diseases (PRD) course. Pre-class reference "Paniker's Textbook of Medical Parasitology 8th edition" was sent as PDF file to the students through the learning management system (Blackboard) 3 days before the session according to the college regulations. The Medical Parasitology tutor facilitated the TBL by preparing the iRAT and tRAT questions, giving the mini lecture, and leading the discussion with the students in the application exercise. The steps were presented as seven MCQs with

Table 1. Specific learning outcomes (SLOs) in each TBL activity.

TBLs	Title	Specific learning outcomes (SLOs)
1	Immunity against parasites	<ol style="list-style-type: none"> 1. Outline forms of innate immunity to parasitic infections. 2. Define concomitant immunity in schistosomiasis. 3. Describe mechanisms of concomitant immunity in schistosomiasis 4. Explain how the parasite evades host immune response with examples 5. List indications for immunodiagnosis of parasitic diseases.
2	Medical Parasitology	<ol style="list-style-type: none"> 1. Outline morphological characteristics, classification, and multiplication methods of medically important protozoa. 2. Describe morphological stages, habitat, life cycle, transmission, and clinical significance of <i>E. histolytica</i>/<i>E. dispar</i> (as a model example of Protozoa).
3	Parasites of the reticuloendothelial system	<ol style="list-style-type: none"> 1. Outline components of the reticuloendothelial system (RES) cells. 2. List the parasites that inhabit the RES cells. 3. Describe morphological features of RES parasites. 4. Discuss transmission, pathogenesis, clinical presentation, and diagnosis of infections caused by RES parasites.

the option to select the best response (iRAT). Twenty minutes were allowed for iRAT. After breaking the students up into smaller teams, tRAT was implemented. For instant feedback using IFAT cards, each team was given a scratch card. Each team included ten students. In order to give students enough time to negotiate and have team conversations in order to arrive at the right answers, 20 min were allocated for tRAT. To verify the correct responses to the unclear questions, an appeal was made. Ten minutes were allocated for the appeal. To clarify the challenging learning objectives in that subject, a mini lecture using a PowerPoint "Microsoft 365" presentation was conducted. The brief lecture was scheduled for 30 min. A problem-solving exercise was provided to gauge how well teams applied the 4 S's of the challenge. The teams' mastery of the higher cognitive levels of Bloom's taxonomy regarding the Parasitology topics was evaluated using an application exercise. Forty minutes were allowed for the problem-solving and application exercise. The score split for the summative TBL was as follows: 70% iRAT, 20% tRAT, and 10% application tasks^[15].

Achievement assessment: All MCQs were approved by the Basic Medical Science Department, and then revised by the course committee and student assessment committee (SAC). Item analysis was performed for all sets of MCQs for difficulty and discrimination, and no items were found with poor discrimination (<50% of students). All MCQs were derived from a previously designed and approved blueprint, and were classified according to Bloom's taxonomy into 30% knowledge and 70 % skills and AEs. Results of the iRAT and tRAT in all MCQs were used to assess the achievements. It is worth noting that the SAC policy allows repetition of not more than 30% of the questions in the final examination.

Perception assessment: A survey was designed to measure students' perceptions toward TBL as an educational strategy in Medical Parasitology. It

consisted of nine closed ended questions using a five-point Likert scale. The students were asked to rank their feedback: 1 (strongly disagree), 2 (disagree), 3 (neutral), 4 (agree), and 5 (strongly agree). Additional one open-ended question was formulated in which the students were requested to write narrative comments regarding their perception and the challenges they faced during implementing TBL for studying Parasitology. The survey results were collected and assessed for internal consistency and reliability using Cronbach's alpha test^[16]. Spearman's rho coefficient was used as a nonparametric measure of the strength and direction of association existing between two variables and to assess survey validity^[17]. The average points on the Likert scale responses for each item were expressed as the mean±standard deviation (±SD). The qualitative, open-ended comments were analyzed by two independent investigators using open coding, then categorized into key concept groups. Each comment was labeled as related to the following two themes: challenges faced and the suitability of TBL in Parasitology learning. A final round of axial coding was implemented to confirm the collection of all important concepts. To determine the appropriateness of the data to proceed with factor analysis, reexamination of the survey validity was performed using Kaiser-Meyer-Olkin Measure (KMO) of sampling adequacy that indicates the proportion of variance in variables that might be caused by underlying factors. Bartlett's test of sphericity was performed as an indicator of the strength of the relationship among variables^[18-20].

Statistical analysis: The data were subjected to statistical analysis using Statistical Package for the Social Sciences (SPSS) software, version 22 (IBM Corp., Armonk, NY). Kendall's tau-b correlation and factorial analysis were calculated. Paired and independent sample t-test were used to compare between the marks of iRAT and tRAT assessments. Cohen's d test was performed to measure the strength of the relationship between TBL' iRAT and tRAT and between

the achievements in the two successive academic years. Results were considered significant when the *P* value was less than 0.05.

Ethical consideration: The study was approved by the National Research and Ethics Committee, College of Medicine, University of Bisha. Students' acceptance of enrolment was considered as consent.

RESULTS

The number of batch 2021-2022 students who attended the three TBL activities was 75 out of total 81 (92.6%). Out of the attendants, there were 41 (54.7 %) male students and 34 (45.3 %) female students. Students of the academic year 2020-2021 were 48 (60%) males and 32 (40%) females.

Students' achievement: There was a significant ($P < 0.001$) increase in the mean \pm SD of the marks in the tRAT compared to iRAT for the same group of students (96.13 \pm 3.39, and 70.29 \pm 12.52, respectively) (Figure 2A). The independent sample *t*-test showed a statistically significant ($P < 0.001$) increase in the mean \pm SD of the marks among students that were taught through TBL and traditional lectures (78.81 \pm 16.74, and 53.39 \pm 18.667, respectively) (Figure 2B). Students' grades in the iRAT and tRAT or tRAT and final exam after both types of activities (traditional lectures and TBL), were 2.017 and 1.434, respectively.

Students' perception: The survey was completed by 60/81 students (72.83%) registered in the academic year 2021-2022 after the implementation of TBL. Thirty-six (60%) students agreed that pre-class study enabled them to answer the iRAT well. Forty (66.6%) students reported that pre-class study enabled them for effective group discussion during tRAT. Fifty-one

(85%) students chose the mini lecture as an effective tool that supported their understanding of Parasitology topic. Forty-eight (80%) students were satisfied with the application exercise as it empowered them to check their understanding of the whole topic. Students also found the activity supported their communication skills, dealing with innovative learning technology, the learning competencies of medical students, learning Parasitology curricula, and engagement throughout the activity time with percentages of 68.4%, 58.4%, 53.3%, 56.7%, 60%, respectively (Figure 3).

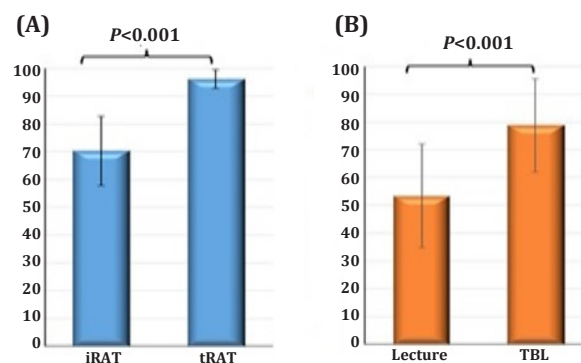


Fig. 2: (A) Comparison of students' achievement in iRAT and tRAT of batch 2021-2022. (B) Comparison of students' achievement in the final exam MCQs touched the Parasitology topics of interest for batch 2020-2021 (lecture learned) and batch 2021-2022 (TBL learned).

The Cronbach's alpha for all items of the survey was 0.664. Spearman's rho coefficient was calculated between different items and between items and total giving ranges from 0.002 to 0.44 and from 0.04 to 0.64, respectively (Table 2). Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was 0.674. Bartlett's test of sphericity was considered significant ($P < 0.001$). By factor analysis, four factors were extracted from

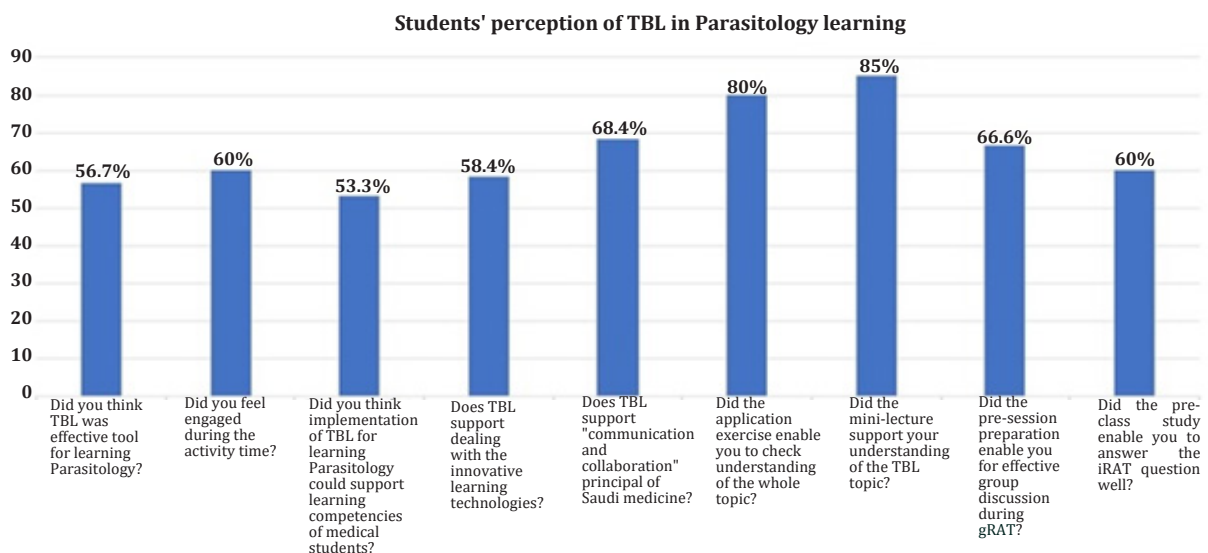


Fig. 3. Students' responses regarding their perception of TBL as an effective learning tool generally and in learning Parasitology specifically. **gRAT:** Group readiness assurance test (synonymous of tRAT).

Table 2. Nom-parametric Spearman's rho correlation matrix (item-item and item-total correlation).

	Item 3	Item 4	Item 5	Item 6	Item 7	Item 8	Item 9	Total
Item 1	0.318*	0.274*				0.260*	0.256*	0.537**
Item 3		0.443**	0.391**	0.257*			0.305*	0.565**
Item 4			0.342**		0.261*			0.445**
Item 5				0.319*				0.458**
Item 6						0.310*		0.437**
Item 7						0.268*	0.319*	0.644**
Item 8								0.562**
Item 9								0.574**

*: Correlation is significant at the 0.05 level. **: Correlation is significant at the 0.01 level.

Note: Only significant values were mentioned.

the questions covering student engagement, pre-class preparation, group discussion and student opinion. The four factors explained 67.43% of the cumulative variance: 30.04%, 13.48%, 12.34% and 11.57% for the four factors in order.

The open-ended comments from the questionnaire were qualitatively analyzed and assigned into two main themes: challenges faced during implementation and general perception regarding TBL for learning Parasitology. Students' comments were categorized into four main challenges; 1) Shortage of pre-class time (17 students, 28.3%); 2) The difficult language of the reference textbook with deficient illustrations (17 students, 28.3%); 3) The stress of assessment and activity conduction (14 students, 23.4%); and 4) Activities carried out during TBL conduction, especially tRAT (12 students, 20%). Perception comments were classified as positive, negative, or suggestions for improvement for each topic area.

Forty-four students (73.3%) reported satisfaction of using TBL in Parasitology learning. Among their comments: "It's the best and effective activity compared to the other", "The perfect teaching tool for Parasitology", "Good for working in group and easy understanding", "It was interesting and really enjoyed" and "It's great, I feel it's much better to study these kind of topics as TBL than as lecture, so we can have a previous knowledge before discussing it with the tutor". Sixteen students (26.7%) felt worried about Parasitology self-learning in TBL. Among their comments are "TBL is not the best tool, it heavily relies on the student's ability to learn information for the first time and therefore leads to more memorizing than understanding", "Parasitology is better studied as a lecture for better understanding" and "Not good because Parasitology needs explanation and clarification". Many suggestions were recorded from students' comments to ensure the consolidation of their knowledge. Most of them (65%) suggested enriching TBL with more illustrations and pictures for better understanding. Twenty percent of students proposed allowing more time for pre-class preparation and carefully selecting the topics for TBL. The remaining 15% reported the need for more diverse references to improve their knowledge and understanding.

DISCUSSION

A recent trend in medical education is the transition from teacher-centered forms to student-centered integrated models. It is strongly encouraged to use more active learning tools instead of passive learning methods, e.g. lectures^[21,22]. Besides, it is essential to identify and gauge student readiness skills, engagement, and knowledge by utilizing a variety of student-centered active learning approaches with a variety of objective assessment strategies^[23]. Recently, TBL has been incorporated into various curricula at a number of medical colleges in KSA, including Al Qassim College of Medicine and Fakeeh College for Medical Sciences^[24,25].

In the present study, there was a significant increase ($P < 0.001$) in the mean \pm SD of the marks in the tRAT compared to iRAT for the same group of students. This concurs with a study that reported tRAT as an effective tool to enhance students learning as all team students made an effort to participate in discussion. It also proved that competitiveness between groups enhanced the learning process^[26]. It was reported that numerous pieces of evidence indicated that the worst-performing team will typically receive a higher grade than the top student^[10].

There was a statistically significant increase ($P < 0.001$) in the mean \pm SD of the final course marks for the questions related to Medical Parasitology topics among students who were taught through TBL and traditional lectures. This agrees with a study conducted at King Abdulaziz University^[27] to compare the students' achievement in Clinical Biochemistry course taught either *via* TBL to 2nd year Clinical Nutrition students or *via* traditional lectures to the same year nursing students. They reported a statistically significant difference ($P < 0.001$) in the post course examination results of recall questions in 2nd year Clinical Nutrition students compared to nursing students in the results of reasoning questions, and in the total scores of both groups. This also concurs with a meta-analysis study in which TBL significantly increased students' theoretical examination scores when compared with lecture-based learning (LBL)^[28]. In addition, Kim *et al.*^[29] discovered

that students in the TBL group (no.=32) at the 1-week post-test had higher exam results than those in the LBL group (no.=31). Moreover, Zhang *et al.*^[30] performed a systematic review by gathering and comparing data of 10 manuscripts that compared TBL versus LBL. They concluded that TBL was a successful learning tool for raising students' academic standard and all-around aptitude with comparison to LBL.

Besides, 68.4% of students found that TBL activity supported their communication skills. In 2020, a study reported TBL as an innovative learning tool that enhanced communication and teamwork skills among students by combining independent out-of-class preparation with in-class discussion^[31]. In the present study, students experienced TBL as supportive tool for their engagement throughout the activity and they were also satisfied with the application exercise as an empowering tool for understanding of the whole topic by 60% and 80% respectively. Ulfa *et al.*^[32] performed a classroom engagement survey and proved that TBL interestingly promotes students' engagement by encouraging discussion. Yang *et al.*^[33] observed excellent levels of student engagement and favorable sentiments of TBL.

The main challenges recorded by analysis of the students' responses are shortage of pre-class time, the difficult language of the reference textbook with deficient illustration, the stress of assessments at the time of the activities. El-Ashkar *et al.*^[34] reported more or less similar results in a previous study for the main challenges in flipped classroom (FC) learning tools including TBL. They included shortage of time (42.55%), earlier work obligations with other summative activities and quizzes (27.66%), and quality of the learning material (21.28%). Notably, other studies reported the self-study at home with lack of available guidance during the pre-class phase of FC as the main challenge for TBL tool^[27,35,36]. Inability to manage time at home was also recorded with that type of student centered activities^[37].

Worthwhile, 44 (73.3%) students reported satisfaction of using TBL in Medical Parasitology learning. This result is comparable to a study that found although TBL adoption was generally well-liked, but students' willingness to support it was low because of the workload of the pre-class preparation^[38]. The majority of students reported that the pre-class study enabled them to answer the iRAT well with effective group discussion during tRAT (60%, 66%, respectively). The mini lecture was reported to support understanding by 85% of students. This concurs with studies that reported good performance of students in iRAT and well preparedness for discussions in tRAT as well as readiness for better knowledge acquisition and deeper understanding of topics illustrated by the mini lecture^[39,40].

Moreover, 58.4% of students found TBL activity supports their dealing with innovative learning technology, and 53.3% reported that TBL supported their learning competencies. This concurs with studies that highlighted the importance of new technology in enhancing the learning process. This enables the medical educators to develop and deploy a number of student-focused, self-directed active learning methodologies, rapid technological improvements as patient oriented problem solving, TBL, CBL, and PBL^[41-45]. This needs a comprehensive faculty development program in order to help tutors to master these activities to optimize the students learning benefits^[46].

Limitations and challenges: The ability of students to comprehend the references in the textbook, participate in productive discussions, express their views, and communicate clearly throughout educational activities is governed by their level of English proficiency. It is challenging to solve real medical problems which requires the presence of clinical cases. However, there are no cases because there are no university hospitals and students must completely rely on the "King Abdullah Hospital" that is run by the "Ministry of Health in KSA" for their training. Since our college is a new medical college with a small annual enrollment, few students participated in this study. For the sake of validation, this study depended on analysis of the students' results for only three TBL activities and compared them with the results of the students who studied the same Parasitology topics by the same tutor through traditional lectures and exposed to the same questions in the final course exam.

By implementing TBL, instructors can increase student involvement and help them make the most of the limited classroom time available for useful discussion and practical application of the learned material. To improve student satisfaction and assist them in reaching the higher cognitive levels of Bloom's taxonomy in learning medicine for the best medical practice in the future. The study concluded that TBL is an innovative directed self-learning tool that should be taken into consideration in all medical schools adopting student-centered learning approaches. It is strongly advised that the new professors participate in a thorough orientation program that includes focused seminars on the conduct of TBL.

Acknowledgment: We would like to acknowledge the administration of the College of Medicine, University of Bisha for their sincere help and support.

Author contribution: El-Ashkar AM contributed in designing the plan of work, and analyzing the data. Aboregela AM performed the statistical analysis. Alam-Eldin YH performed data analysis and interpretation of results. Metwally AS critically revised the manuscript. All authors shared in writing and revising the manuscript. The manuscript has been read and

approved by all named authors who further confirm the order of listed authors.

Conflict of interest: None.

Funding statement: There is no financial support for this work that could have influenced its outcome.

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