

Team-based learning versus problem-based learning in medical education: A systematic review

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ABSTRACT

Objectives: Problem-based learning (PBL) has been widely used in medical education since the 1960 s. In recent years, team-based learning (TBL) has gained popularity and has been applied in various medical and other professional institutions around the world. The objective of this systematic review was to identify which teaching pedagogy, TBL or PBL, is more effective in delivering medical education. **Methods:** The authors searched PsycNet, ERIC, and PubMed databases for articles on TBL and PBL in regards to medical education, published between 2002 and 2020. The articles were selected and reviewed by the preferred reporting items for systematic reviews and meta-analysis statement framework guidelines. **Results:** The authors identified 15 articles after full-text screening that satisfied their inclusion criteria. Of the 15 articles, 12 incorporated a modified TBL format, while three described classic PBL. **Conclusion:** Overall, the majority of the articles demonstrated a positive learning experience of TBL programs. There are pros and cons to both TBL and PBL. The advantages include promoting critical thinking and fostering collaboration, while disadvantages are lack of motivation and poor clinical problem solving. In the future, finding a way to merge both of these teaching methods might optimize learning experiences in medical education.

Key words: Critical thinking, Curriculum, Problem-based learning, Team-based learning

Medical curricula have been incorporating new teaching methodologies for the past several decades. Of these, collaborative learning, such as team-based learning (TBL) and problem-based learning (PBL), has been extensively explored to see how well they integrate into medical schools. TBL is a learner-centered and instructor-led method that consists of active learning, small collaborative teams, and full classroom discussions [1,2]. TBL has been introduced in medical education since the early 2000 s and was originally developed by Dr. Larry Michelson for business schools [2,3]. PBL is a student-driven teaching method that involves analyzing cases in small groups facilitated by instructors and was developed in medical education in the late 1960 s [4,5]. Both TBL and PBL utilize a student-centered approach, small groups, and clinical problems/cases [5]. In addition, both of these have been adopted by medical schools globally as an alternative to the prominent lecture-based teaching, to emphasize clinical reasoning and problem-solving [5].

Although multiple studies have been performed analyzing the

effectiveness of TBL and PBL in medical education, to date there have been very few qualitative syntheses of the TBL and PBL literature [1,6]. Therefore, the purpose of this study was to conduct a qualitative systematic review assessing the effectiveness of both of the teaching pedagogies in delivering medical education. The search strategy for our review was guided by preferred reporting items for systematic reviews and meta-analysis statement.

METHODS

We searched three databases for TBL or PBL publications, including PsycNet, ERIC, and PubMed. In the PsycNet database, we used the following search terms: TBL, PBL, medical school, program evaluation, feedback, curriculum, students, effectiveness, and dental school. In the ERIC database, we used the following search terms: TBL, PBL, medical school, program evaluation, feedback, curriculum, students, and effectiveness. Finally, in the PubMed database, we used the following search terms: TBL, PBL, medical school, program evaluation, feedback, curriculum, and students. To be included in the systematic review, articles had to meet the

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following criteria: (a) Published after 2001; (b) peer-reviewed articles only; (c) full-text available online; (d) only journal articles; (e) students in secondary, postsecondary, graduate or professional education programs; and (f) English language only. We excluded non-peer-reviewed articles published before 2001 and non-academic sources, such as reports or press releases. Since the primary focus of our systematic review was on graduate or professional education programs, we excluded articles reporting on students in elementary to high school programs. Finally, we excluded expert opinions, books, editorials, letters, and commentaries that did not contain primary research on TBL or PBL programs.

Our literature search yielded 170 potential publications on TBL and PBL in medical programs, of which 71 are from PsycNet, 58 are from ERIC and 41 are from PubMed (Fig. 1 for complete search strategy). Following an initial screening of the titles and abstracts for relevancy, we narrowed down the list to 16 articles in total: One article from PsycNet, three from ERIC, and 12 from PubMed. Two coauthors independently reviewed the full-text of all 16 articles and came to the conclusion to exclude one article. This article from ERIC was not relevant to our scope of study because the students did external placements, so the article did not focus on TBL or PBL in the medical classroom. From this full-text analysis, we extracted data and organized it into a PICOS

table, with the following subheadings: Article; problem/patient/population/participant; intervention/indicator; comparison; outcome; and study design.

We considered a classic TBL program as one that included four phases: (1) Individual pre-class preparation, (2) individual readiness assurance test (iRAT), (3) team readiness assurance test (tRAT), and (4) immediate feedback (refer to Appendix 1). We considered TBL programs to be modified if they did not include one or more of these four phases or if any of these phases were significantly altered or if additional phases were implemented for the TBL sessions. Likewise, we considered a classic PBL program as one that includes three phases: (1) Initial group discussion, (2) individual self-study, and (3) final group discussion. A program is considered modified PBL if it did not include one or more of these three phases or if any of these phases were significantly altered or if additional phases were implemented for the PBL sessions.

Although, limited supplementary lectures that occur after phase two or three are still considered part of the classic PBL format [5].

RESULTS

Of the 15 included articles, none of the articles described a classic TBL program, while 12 (80%) described a modified

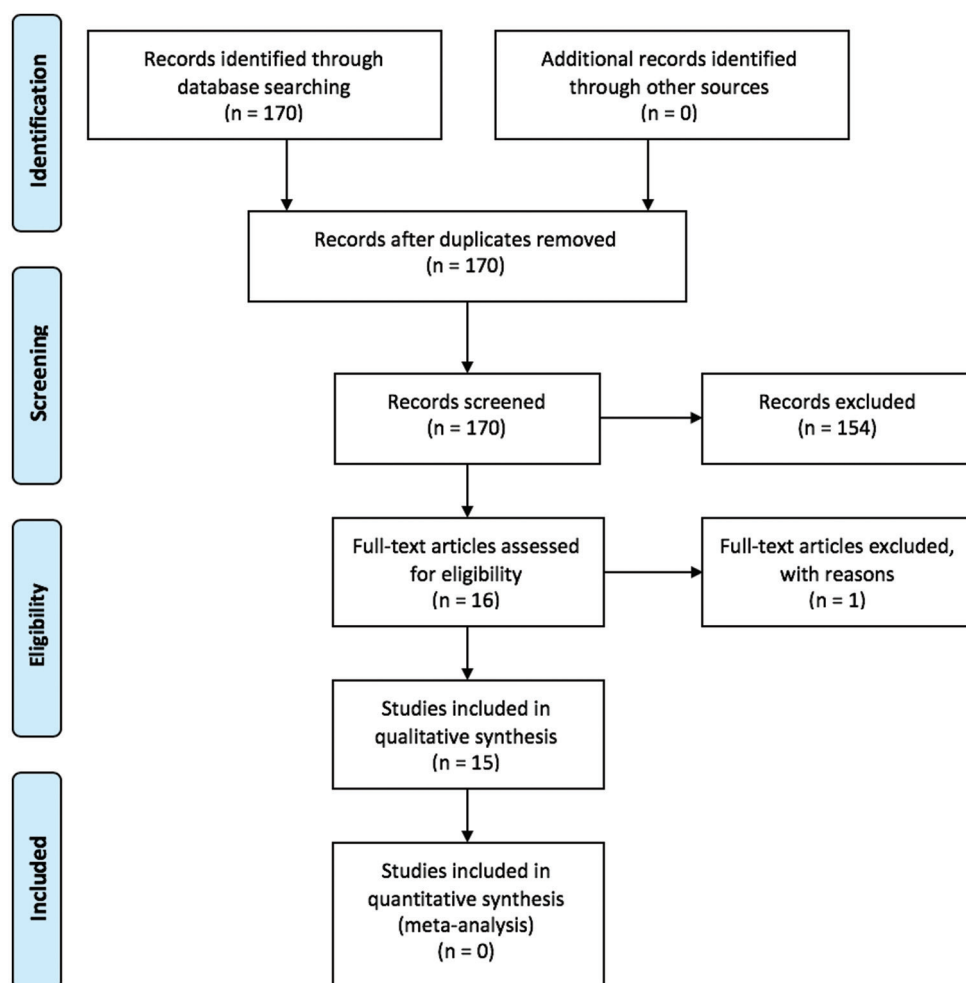


Figure 1: Flowchart of the literature search and study selection process in a systematic review of the literature on team-based learning and problem-based learning programs in medical education published between 2001 and 2020

TBL program (refer to Appendix 2) [1-3,6-14]. Three (20%) articles described a classic PBL program [1,4,12], with student or instructor led sessions, while one (0.1%) described a modified PBL program using student or facilitator led sessions followed by questionnaires [1,3,6,12].

Nine (60%) articles were in favor of the TBL program [3,6-8,10-13,15], one preferred PBL [4], two (13%) had mixed results [9,12], and three (20%) were inconclusive [1,14,16]. Specifically, one article was in favor of PBL when comparing it to didactic lectures [4] and two (13%) articles were in favor of TBL when comparing this format to traditional teaching through lectures [2,10].

The studies were conducted in the following seven countries: Tokyo, Finland, Turkey, USA, Tanzania, Australia, and Korea. Australia was the most commonly represented country, with 5 (33%) studies all at the University of Sydney [1,6,8,9,11].

Both TBL and PBL are used in various medical curricula, including multiple disciplines, such as pediatrics, gynecology, otorhinolaryngology, acute medicine, biochemistry, ophthalmology, cardiology, musculoskeletal, physiotherapy, rheumatology, dental and medical physiology, respiratory, and parasitology.

Qualitative analysis

A content analysis was conducted by classifying and summarizing data. The article content was analyzed to see if they meet a classical TBL or classical PBL. For a classical TBL, we analyzed four phases and for the classical PBL we analyzed three phases (as described in methodology section) (refer Appendix 3).

DISCUSSION

This systematic review examined the role of TBL and PBL in medical education. Specifically, it evaluated whether there are advantages and disadvantages with both of the models in medical learning. It revealed a large number of variations in study design and outcome measures. Due to the heterogeneity of the studies, it was difficult to assess the overall utility and effectiveness of both TBL and PBL in medical curriculum. Despite the vast differences, the overall outcomes of most of the studies were in favor of incorporating a TBL program in medical schools and other professional schools.

Overview of TBL

When compared to traditional lecture-based teaching, TBL produced better learning outcomes and higher examination scores (Appendix 4) [3,10]. In a study conducted by Nyindo *et al.* that included 158 MD2 students, they found improved examination scores using the TBL approach taught in 2012 then the didactic approach used in 2011 [10]. Examination scores during the first quartile of the 2011 MD2 class went from 60% to 71% in 2012. During the second quartile, the median scores improved from 65% in 2011 to 74% in 2012. Similarly, examination scores increased from 71% in 2011 to 80% in 2012 in the third quartile [10]. In

addition, the majority of students found that TBL consisted of better learning objectives was more interesting and better to understand, increased student participation, and was overall satisfactory [2]. However, the effect of TBL is not universal, meaning that the positive results of TBL were larger for courses in medical schools in comparison to other educational fields [3]. In addition, the positive perception of TBL effectiveness was not only beneficial to student learning, but also to their understanding of class content and performance on examinations [7]. Compared to PBL, many students found that the small groups, iRATs, immediate instructor feedback, pre-reading, and engagement of TBLs to be positive [1]. TBL teaching methods are attractive as it spares faculty time, especially in low-resource settings where infrastructure can be inadequate, class sizes may be too large and not enough qualified instructors might be available [10]. It seemed as though students appreciated the TBL learning method, as it helped consolidate their learning and promoted clinical reasoning.

[11] Adding to this, clinical reasoning ability scores were found to be significantly higher in TBL than non-TBL methods [12].

Furthermore, students found that TBL was more effective in areas of problem solving, both individually and in teams, and that it is used in improving clinical reasoning ability in students with PBL experience who have limited clinical exposure [12]. When comparing TBL learning amongst ranking of students based on test scores before and after iRAT, it is found that TBL helps low-ranked students improve their grades significantly compared to higher ranked students [13]. Clinical problem solving within TBL was found to be less effective, as more time was needed for this phase [1]. Another disadvantage is that the TBL is not able to maintain the motivation of students throughout the course. For example, the study by Fujikura *et al.* identified that students found TBL to be 7% effective at the beginning of the course, 14% in the middle and 11% at the end [14]. One of the ways to potentially increase motivation was through the high quality of materials presented, especially during the application phase of the TBL session. An interesting find was that instructors felt the preparation for TBL was burdensome. A common downfall of TBL was that there was a mismatch between contents presented in the TBL sessions and subjects evaluated on examinations of regular courses [14].

Based on the results, it is evident that TBL is more effective in creating a positive learning environment and experience that is conducive to enhance student learning [7,15]. The modified TBL formats across the various studies were perceived to be less stressful, not as difficult as the classic TBL design and fairer in terms of evaluations [7]. The pre-readings and/or pre-recorded lectures for TBL sessions ensured students had sufficient requisite knowledge and also increased their class engagement [8]. The tRAT and small groups increased collaboration and teamwork. Specifically, tRATs promoted inter-team competition and active discussion within teams, while small group sizes motivated preparation and contribution to discussions. Furthermore, iRATs and tRATs reinforced key concepts [9]. The structure of the TBL sessions made students accountable for their learning and team

contributions [8]. In addition, TBL methods provided student-centered teaching strategy to support in the achievement of interprofessional learning goals. Working in teams has enabled students to value their interactions with their peers from different professional degrees, and it provided opportunities to collaborative problem-solving while learning different perspectives on patient cases [11]. Finally, the studies which included authentic clinical problems in the modified TBL format, improved student understanding by self-reflection, identifying knowledge gaps, and building on prior knowledge [8]. All in all, the standardization of the TBL format was a plus point for the students [9].

Overview of PBL

Students found clinical problem solving to be more effective in the PBL format [1,9]. PBL tutorials were better in providing more freedom in problem-finding, concentration in personal interests, and open for longer discussion [12]. In addition, PBL tutorials' self-learning characteristics were found to be more effective in understanding learning objectives [12]. In the study conducted by Eskola, the results indicated that students developed more information literacy skills through PBL instruction, compared to traditional curriculum [4]. More students in PBL had developed information literacy skills, while traditional teaching resulted in undeveloped information literacy skills. In particular, students in the PBL curriculum were highly critical of the information and of the sources of information [4]. A common disadvantage of the PBL curriculum is that students felt their learning was dependent on the PBL tutor assigned, so they preferred clinicians to be their tutors, rather than upper year students [9]. Students found it better if the tutorials were delivered at relevant times (i.e., when students needed the information for their projects) [4].

TBL versus PBL

Both TBL and PBL foster a joint purpose and collegial atmosphere due to the collaborative learning experience. Furthermore, TBL and PBL both promote critical reflection due to clinical problem-solving activities in TBL and individual work on cases (without direct supervision) in PBL. A re-emerging theme was that TBL can help students develop a depth of knowledge in basic science, which PBL could not provide [9]. Furthermore, it is interesting to note that despite all the benefits of TBL, one study found that students rated TBL as the least effective learning method; 11% compared to 21% for PBL, 29% for lectures, and 39% for self-learning [14]. This could potentially be due to the fact that didactic and self-learning are the pioneers in teaching methods and PBL has also been in medical education for a long time, but TBL is a fairly new concept. Nevertheless, 39% of instructors agreed TBL would be a good substitute for PBL. TBL is claimed to be a more impressive learning method to entrench learning objectives compared to other teaching methods [12].

Limitations

Although we attempted to collect relevant and comprehensive articles, this systematic review has potential limitations. First, it is important to note that some studies found TBL to be effective in promoting critical thinking [12], while others did not. On the contrary, a few articles found PBL to be effective in promoting critical thinking [1]. Second, while our aim was to directly compare the effectiveness of TBL versus PBL in medical education, a couple of studies in our systematic review used other teaching methodologies for comparison, such as traditional lectures versus TBL and traditional lectures compared to PBL. Although PBL has been present for much longer than TBL, the articles generated by our search strategy heavily encompassed TBL articles, posing a selection bias in which, the articles obtained are not representative of the ones intended to be analyzed. As a result, we had much more discussion on TBL than PBL, leading to a confirmation bias with the availability of more data supporting TBL. Finally, a potential confounder is the learning environment of a particular region. Since Australia was the most represented country, the results may be skewed and perhaps the outcome may have changed in a developing country setting, such as African or Asian countries. In turn, these limitations might create a perceived bias and limit potential conclusions that can be drawn.

CONCLUSION

TBL and PBL both have their pros and cons and they both offer enriched learning experiences, which traditional methods may lack. PBL is focused on self-directed learning and offers the opportunity to apply that learning to solve complex and clinical cases. TBL emphasizes collaboration and collective thinking, making students accountable for their learning and team contributions. Therefore, to optimize the effectiveness of each individual method, we propose bridging these two methods together to complement each other, ultimately offering the most optimal learning strategies. Consequently, this hybrid TBL-PBL program may help to develop medical professionals that can deal with complex problems more effectively because of their ability to collaborate in multi-disciplinary teams. With the higher level of thinking obtained through the hybrid TBL-PBL curriculum, these medical professionals may be better equipped to address evolving health diseases and patterns.

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APPENDICES

Appendix 1: Main characteristics of PBL and TBL

Instruction characteristic	PBL	TBL
Materials	Learning by addressing professionally relevant problems. All students work on the same problems.	Learning by addressing professionally relevant problems. All students work on the same problems.
Format	Learning in small groups.	Learning in small teams.
Teacher	One teacher facilitates each small group.	One teacher facilitates numerous small teams (20 or more).
Group activities and self study	Students start with an initial discussion in the group to determine issues that need further self study. All students study the same set of learning issues during individual self-study. Thereafter the group meets again to share and discuss findings.	Students start with mandatory pre-assigned reading during individual study. Students fill out a test (individually). Thereafter students discuss the exact same test items to reach team consensus and receive immediate feedback on their answers.
Group characteristics	Six to ten students per group. Students are randomly assigned to the groups. Group members stay together in a group for 6-10 weeks and discuss several problems.	Five to seven students per team. Students are purposefully assigned to the teams. Group members stay together in a team for atleast the duration of a course.
Other curricular activities	A limited number of supplementary lectures are included which take place after self-study and after the final discussion in the small group.	There are no traditional lectures. Student's initial exposure to the content is through pre-class study assignments and instructor's input is either corrective or confirmatory in nature and occurs: (1) at the conclusion of the team readiness tests and, (2) at the conclusion of the plenary class discussions in which teams have challenged each other's answers.

Appendix 2: Various TBL course structures in medical education published between 2005 to 2020

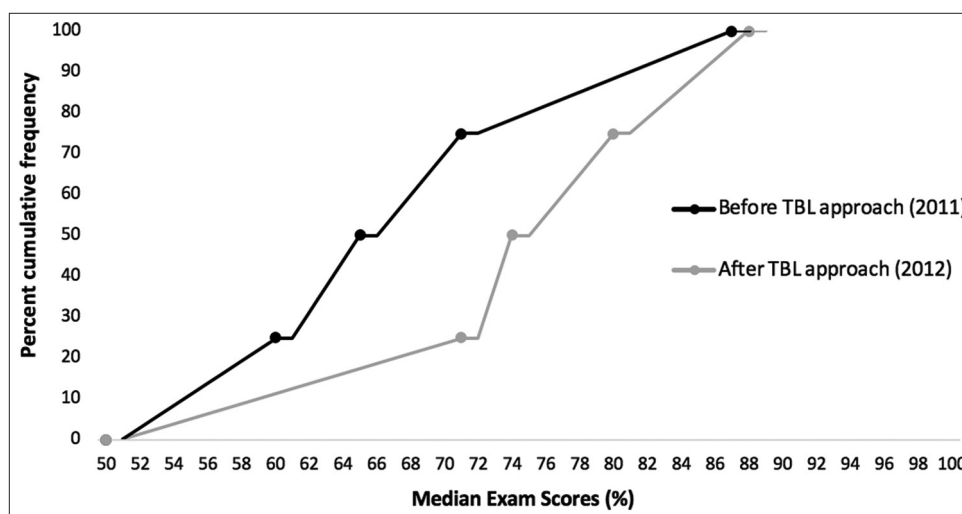
Article title	TBL format
The effectiveness of TBL on academic outcomes: A meta-analysis	multiple formats based on articles included in meta-analysis
A Comparison of TBL Formats: Can We Minimize Stress While Maximizing Results?	iRAT, tRAT, iSAT (individual Summative Assessment Test), scratch-off, lottery-style cards for teams to receive immediate feedback, and survey
TBL in the medical curriculum: Better than PBL?	pre-class reading, iRAT, tRAT, feedback, clinical problem-solving activities and questionnaires after each block (closed and open-ended questions)
TBL: A community of practice	pre-class reading, iRAT, tRAT, feedback, clinical problem-solving activities, focus groups for students, and interviews for facilitators
Implementation of modified TBL within a problem-based learning medical curriculum: A focus group study	pre-class reading, iRAT, tRAT, immediate feedback, and clinical problem-solving activities
Introduction of TBL at Kilimanjaro Christian Medical University College in Tanzania: Experience with the ectoparasites module	background readings, iRAT, tRAT, module (YouTube video), feedback, and questionnaires
Implementation of TBL in year 1 of a PBL based medical program: A pilot study	pre-reading, iRAT, tRAT, feedback, problem-solving activities, and questionnaires (open and closed Qs)
Interprofessional TBL: How do students engage?	pre-reading, iRAT, tRAT, feedback, clinical problem-solving activities, and questionnaires (closed and open-ended questions)
Modified use of TBL in an ophthalmology course for 5 th -year medical students	Three phases: Pre-class prep, iRAT+tRAT+feedback, and post-class reflection
TBL, a learning strategy for clinical reasoning, in students with problem-based learning tutorial experiences	pre-class prep, iRAT, intra-team discussion, tRAT, immediate analysis of scores using response analyzer system, inter-team discussion, feedback, application to solve clinical case, and peer evaluation
Verification of learner's differences by TBL in biochemistry classes	advance assignment, debate, iRAT, debate, tRAT, feedback, and individual achievement test
TBL using an audience response system: A possible new strategy for interactive medical education	IRAT using audience response system (ARS), gRAT, immediate feedback using ARS, questionnaires at beginning, middle, and end of TBL course

iRAT: Individual readiness assurance test, tRAT: Team readiness assurance test, TBL: Team-based learning

Appendix 3: Content analysis of data from each qualified articles

Step	Process
Step 1 preparing data	The data were prepared by combining everything to an excel sheet. Checked if all studies have enough data and checked for missing data
Step 2 defined unit of analysis	Words, phrases, sentences, and paragraphs were analyzed for themes and coded
Step 3 developed categories and schemes	Two main categories were formed, one for TBL and another for PBL
Step 4 conducted a sample test	A sample test was conducted between two researchers and checked for inter-coder agreement
Step 5 coded all texts	All information from the articles were coded
Step 6 coding consistency assessed	Assessed for coding consistency between the two researchers
Step 7 drawing conclusion	Conclusion was drawn by analyzing the themes of TBL and PBL

TBL: Team-based learning, PBL: Problem-based learning



Appendix 4: Median examination scores of 158 MD2 students in Tanzania compared 2011 didactic teaching program versus the TBL methodology in 2012