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Analysis of the Team-Based Learning Literature: TBL Comes of Age

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Team-based learning, or TBL, is an application-oriented teaching method that combines small- and large-group learning by incorporating multiple small groups into a large group setting. It has been increasingly used in postsecondary and professional education over the past two decades. Given this increasing usage, many faculty wonder about the effects TBL has on learning outcomes. The authors performed a review and synthesis on the educational literature with respect to TBL to examine the quality of their descriptions of core TBL elements, then constructed narrative summaries of these selected articles. Their analysis demonstrated early evidence of positive educational outcomes in terms of knowledge acquisition, participation and engagement, and team performance. The authors conclude that the TBL literature is at an important maturation point, where more rigorous testing and study of additional questions relating to the method are needed, as well as more accurate reporting of TBL implementation.

Introduction

Over the past 20 years, educators in professional schools and on college campuses have increasingly employed an application-oriented teaching method called team-based learning, or TBL (Thompson, Schneider, Haidet, Perkowski, & Richards, 2007). TBL combines small and large group learning by incorporating multiple small groups into a large-group setting (Michaelsen, Sweet, & Parmelee, 2008). Part of TBL's attractiveness to professional schools lies in its combination of efficient use of resources (requiring only one teacher to conduct multiple groups simultaneously) and the promise of high levels of active student participation, which usually is accomplished only through small-group methods (Haidet & Fecile, 2006).

Given the rising popularity of TBL, it is not surprising that many conversations occur among faculty about its use and effectiveness. A common question is whether TBL produces better learning outcomes than didactic lectures. Although there have now been a number of studies published over the past decade, particularly in the health sciences literature, there has not been a systematic synthesis of the literature with respect to TBL. Therefore, we undertook this project to identify and evaluate the existing literature on team-based learning, and to use it to draw evidence-based conclusions about the method.

Methods

We used the Scopus database to search the life sciences, physical sciences, humanities, and social sciences literature, using the terms "team AND based AND learning" and performing text searches of titles, abstracts, and key terms. A second search with the same terms in titles was performed using the Towson University "One Search" engine, which attempts a Google-like search over all subscribed electronic content, including the Medline, Academic Search Premier, and Education Research Complete research databases. We limited the search to published articles and reviews in the English language. The combined searches produced a total of 130 unique articles available as of March 17, 2013. The majority of the articles focused on subject areas in the social sciences, medicine, pharmacology, toxicology, nursing, and business education.

We scanned the abstracts of all identified articles and classified them as being either clearly about TBL, possibly about TBL, or clearly *not* about TBL. We used a two-step process to make this determination. First, we looked for the words "team-based learning" as a single phrase, rather than

as "team," "based," and "learning" in separate sentences in the abstract. Secondly, we scanned for any combination of language terms often used in TBL articles, including "Larry Michaelsen," "active learning," "peer review," "readiness assurance test (RAT), "readiness assurance process (RAP)," "readiness assessment," "4 S," or "application exercise." Using this process, we classified 18 articles as clearly not about TBL and, therefore, excluded them from further review. The excluded articles were about problem-based learning, process-oriented guided inquiry, protected learning time, or other types of group work or team work. A total of 112 articles using the phrase "team-based learning" in the title or abstract remained for more detailed analysis.

Once we had identified this article group, we reviewed all articles for the presence of text describing various aspects of the context and scope of TBL implementation and the seven core elements of TBL, as recommended in reporting guidelines published by Haidet and colleagues (2012). TBL context and scope included class size, team size, number of faculty involved, familiarity of faculty with TBL, the subject matter being taught, the course context of the TBL sessions, and learner familiarity with TBL. The seven core elements of TBL identified by Haidet and colleagues included descriptions of team formation processes, readiness assurance processes, immediate feedback methods, in-class sequencing of learning activities, "4 S" applications, grading incentive structures, and peer review processes. An initial 20 articles were coded independently by all three authors and then discussed in detail to arrive at a consensus as to how the articles would be categorized and what characteristics would be used for coding. The remaining articles were initially coded independently by two of the authors and then discussed to reach consensus. The group reached consensus on all 112 articles.

In our final step, we classified each article as either "full TBL" "partial TBL," or "not TBL," based on our in-depth reviews. Articles classified as "not TBL" lacked a description of a readiness assurance process and an application exercise process that used the "4 S" principles. Articles classified as "partial TBL" typically included a readiness assurance process followed by either no application activities or by other group activities that did not follow the "4 S" principles (significant problem, same problem, specific choice, simultaneous reporting). Of the remaining articles classified as full TBL, we sub-classified this group into articles describing TBL implementations or outcomes, articles that used TBL with minor modifications (for example, using audience response systems to report readiness assurance scores, and the like), and articles that were reviews, commentaries, or guidelines without describing a specific TBL

implementation. For the 40 articles that described full or modified TBL implementations and/or outcomes, we constructed narrative summaries of the content of the evaluations or outcomes reported.

Results

Literature searches using the search terms "team," "based," and "learning" produced 130 articles published since 1996. As illustrated in Figure 1, the number of articles published each year has been increasing. Given that 10 articles were published by mid-March of 2013, the total number of articles published this year is expected to continue this trend.

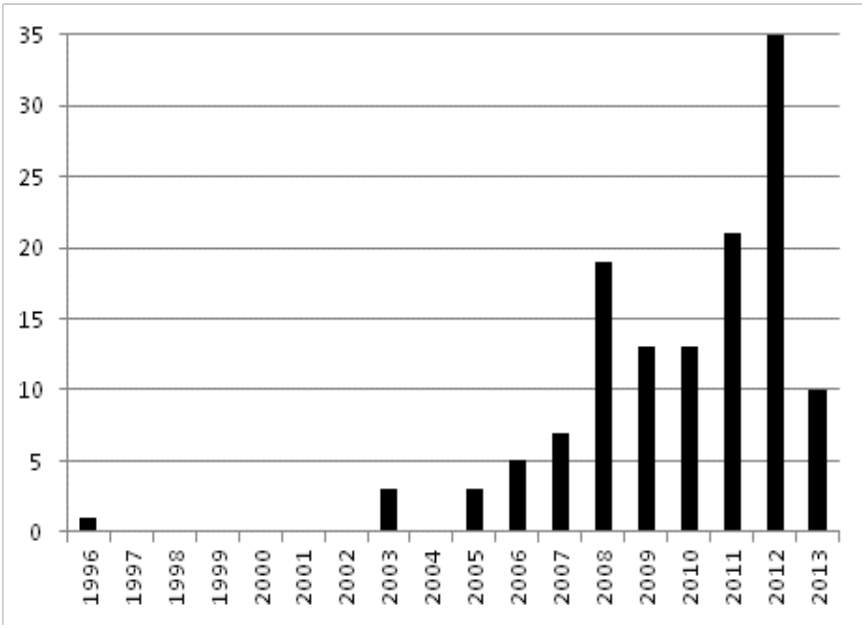
Figure 2 summarizes the decisions made during our characterization of the literature search results. We performed an in-depth review of 112 articles that remained after our initial screen. We designated 28 articles as not describing TBL; these articles generally described forms of teaching that involved small-group or team activities, but they did not include TBL core elements. Most of these non-TBL articles used the term "team-based learning" in a more generic fashion to indicate other learning activities being performed by small groups or teams.

Of the remaining 84 articles, we designated 63 (75%) as fully using Michaelsen's Team-Based Learning method, and 21 (25%) as describing partial implementations of TBL. Of the 63 full TBL articles, only half (33 articles, 39% of the total of 84) described the implementation of TBL for a particular learner group and subject area and/or learning outcomes. Seven articles (8%) used modifications of the method, typically consisting of minor changes in format or sequence of events. Twenty-three articles (27%) consisted of reviews, commentaries, or guidelines for using or reporting about TBL.

Twenty-one articles described partial implementations of TBL. Of these, seven articles described the use of a readiness assurance process only (8%), and 14 articles described readiness assurance followed by other learning activities that did not employ "4 S" principles of TBL applications (17%).

Table 1 summarizes an analysis of the quality of the TBL description for the 40 articles that we categorized as TBL or modified TBL. We used the recommended guidelines for reporting TBL activities to assess their descriptions of context and scope, as well as their inclusion of the seven core elements of TBL (Haidet et al., 2012). As shown in Table 1, all of the articles included a description of the subject matter and the course context (for example, number of TBL sessions, overall course format, how TBL related to other activities). Most of the articles described the overall class and team size, and half mentioned how many teaching faculty were in-

Figure 1
Number of Unique Articles per Year Resulting From Literature Searches tor "Team" AND "Based" AND "Learning"



volved in the TBL sessions. However, most articles failed to describe how familiar students or faculty members were with TBL. Such information is important for interpreting results, because students and faculty often have trouble adapting to some of the paradigm shifts (for example, from passive to active learning, from covering to effectively using content) that are embodied by the TBL method, and this can affect certain learning outcomes (Haidet, Morgan, O'Malley, Moran, & Richards, 2004).

Most of the 40 TBL articles contained descriptions of some or all of the seven core TBL design elements (see Table 1). A majority described the readiness assurance process, including individual and team RATs, sequencing of in-class learning activities, "4 S" application exercises, and team formation methods. Only about half described the remaining core elements, including peer review, details regarding the incentive structure,

Figure 2
Flow Chart Illustrating Decisions Made During Literature Search

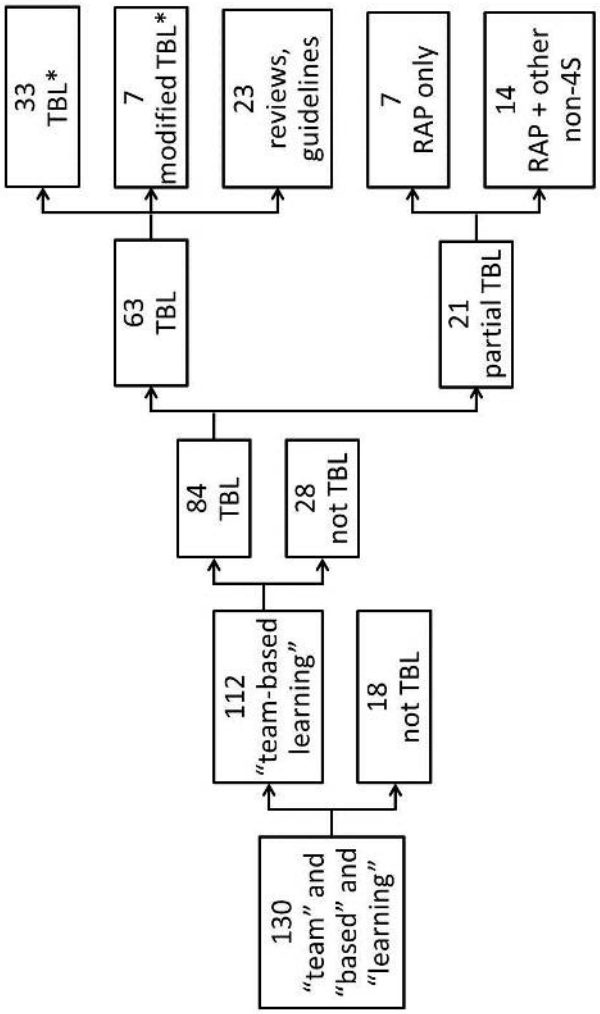


Table 1
Number of Articles Describing TBL Implementation per Recommended Guidelines (from Haidet et al., 2012)**

Context & Scope of TBL Implementation						
Class Size	**Team Size**	**Number of Faculty**	**Faculty TBL Familiarity**	**Subject**	**Course Context**	**Learner TBL Familiarity**
34 (85%)	31 (78%)	20 (50%)	7 (18%)	40 (100%)	40 (100%)	10 (25%)
Core Elements of TBL						
Team Formation	**Readiness Assurance**	**Immediate Feedback**	**In-Class Sequence**	**4 S Applications**	**Incentive Structure**	**Peer Review**
29 (73%)	38 (95%)	22 (55%)	36 (90%)	34 (85%)	22 (55%)	23 (58%)

Note. Total $N = 40$, including TBL Implementation and/or Outcomes and Modified TBL

and methods used to deliver immediate feedback. For immediate feedback, the described methods included Immediate Feedback Assessment Technique (IF-AT) "scratch-off" cards, use of flash cards for team answers, and immediate faculty feedback.

Appendix A describes elements of the content of the forty articles that described full or modified TBL implementations. Details about content for individual articles can be found in the table, and we note some general themes and trends here. The articles listed in Appendix A are referred to in the text by the article numbers. Of the TBL articles published to date, the majority have described a context in the health sciences, with 18 articles focusing on medical education (articles 2-5, 11, 15, 17, 20, 23, 24, 27, 28, 30, 31, 34, 37-39), three on nursing education (articles 1, 6, 7), and seven on undergraduate or graduate pharmacology and pharmacy education (8, 12, 13, 18, 26, 36, 40). Of the remaining 13 articles, three described graduate education (in social work [19], education [22], and public health [35]), eight undergraduate education (in engineering [10], law [9], psychology [14, 32], information management [16], mathematics [25], statistics [29], and communication [33]), and one high school education (obesity education [21]).

Details of the articles' evaluation strategy and experimental design (where applicable) are found in the second column of Appendix A. Sixteen articles employed a comparison group. Of these, 10 compared TBL-taught students to historical cohorts (1, 2, 8, 9, 13, 18, 22, 23, 26, 34), and 14 compared TBL students to concurrent controls, either through comparisons to different levels of learners (4, 24, 39), different sessions (using different teaching strategies) within the same course (6, 14, 15, 19, 23, 27, 30, 31, 40), or traditional controls (7, 37). Three of these articles used an experimental design, with one using randomization of learners (38), and the other two employed a crossover design (30, 31). One article that employed a comparison group examined differences between two types of teachers (teacher trainees versus faculty teachers) (27). The remaining 17 articles described the experiences of learners and teachers without the use of a comparison group.

A variety of data were collected, with some articles describing types and sources of data. These data included student surveys and feedback (25 articles); course data, including examination scores and grades (19 articles); informal observations and conclusions of either the teacher or the author (9 articles); and attendance (1 article). Only seven articles reported the collection of pre- and posttest data, with two assessing knowledge (4, 30), two assessing attitudes toward working in teams (6, 12), and three assessing other characteristics (3, 19, 26). Two articles collected data based on subsequent performance of learners in actual work environments (7,

34). Four articles collected data focused on faculty, including resource utilization and general faculty impressions (8, 11, 35, 40).

The third column of Appendix A summarizes the results of each article. In general, when knowledge acquisition was examined, most articles described improvements for students who experienced TBL, often with comparisons of students at the low and high ends of the class, as defined by other academic measures. Whereas all students tended to benefit from TBL, students at the low end of the class usually benefitted the most (articles 2, 5, 8, 17, 18, 23, 30). Team performance was consistently observed to be positively impacted, both through better performance of teams as compared to individuals on course exams and through improved communication and awareness within teams. Most of the articles that examined learner participation or attendance did so through either direct comparison to or teacher recollection of attendance during lecture-based teaching, and these comparisons consistently suggested that learners demonstrated greater participation in TBL-based classrooms. Data on learner perceptions and attitudes suggested greater self-efficacy and higher interest (articles 9, 19). This was tempered by some studies finding lower student enjoyment or satisfaction (6, 38). Measurements of learner impressions of pedagogical effectiveness and attitudes toward teamwork demonstrated both positive and negative perceptions. In the two studies that tracked learner performance in actual work environments, both suggested that learners were able successfully to transfer TBL classroom learning to improve their job performance (7, 34) Finally, the studies that examined faculty suggested that teachers encountered an initial increase in their workload as they learned the method and prepared course materials and a relatively steep learning curve as they gained experience using the method (8, 10, 36, 40).

Discussion

The TBL method has been in existence for over 30 years. As with many innovations, TBL spread slowly at first, mostly through the business education community and at the University of Oklahoma, where many of its early proponents were faculty members. In the late 1990s, however, TBL began to spread more widely, as educators across disciplines began to espouse its merits and potential fit for the changes that many educational contexts were experiencing. This was partly fueled by an explosion of usage in health sciences settings. For example, in 1998, no medical schools that we know of were using TBL; today, more than 100 schools worldwide are using the method to some extent (personal communication, the Team-Based Learning Collaborative, February 4, 2013). With the widening

usage of TBL, a scholarly literature has begun to grow at an accelerating pace, as we found in this study (see Figure 1). This is a promising sign, because any educational method tends to be rooted in its own historical and cultural context, and only through continued communal conversation can the method evolve and adapt.

As trainers for the Team-Based Learning Collaborative (http://www.teambasedlearning.org), we often conduct faculty development workshops that introduce the method. Some faculty find these workshops challenging, not just because of the complexity of the method, but also because it directly challenges the widely and deeply held assumption that the teacher's role is to impart knowledge to learners. A common question that occurs during introductory workshops is whether students learn better with Team-Based Learning. The answer to such a question depends on how one defines the term "learn better," and, while the assumption that teaching is "imparting" knowledge tends to be concerned only with knowledge acquisition, the studies we examined suggest that the benefits of TBL extend well beyond this singular learning goal.

We have encountered several stories within the TBL community, which, taken together, tend to create a collective narrative—for example: "Team-based learning helps bring up students at the bottom of the curve"; "Team-based learning creates lots of excitement and engagement in the classroom, and that energizes me and my teaching"; and "My students are better prepared to work in teams as a result of my using TBL." For years, some educators discounted these personal stories, acknowledging that, while the stories were compelling, their singular and subjective nature precluded drawing evidence-based conclusions about the method. In this literature review, however, we found a growing empirical literature that supports all of these assertions, plus initial evidence of the transfer of knowledge to application in real-world environments.

We also found evidence that some students and teachers struggle with the method, and view it as less enjoyable, less effective, and less efficient than lecture-based methods. One hypothesis for this finding lies in the knowledge-transfer paradigm (1, 15). Team-based learning asks both teachers and learners to believe that practice with concepts (rather than memorization of or telling about them) in messy, uncertain application exercises is the key to actually being able to use such concepts in real life. Teachers who try TBL but do not actually adopt this practice-based paradigm risk lapsing into didacticism during the session, shutting down learners' creativity, openness, and critical thinking. Learners who experience TBL but do not adopt the paradigm tend to feel cheated out of hearing more facts; thus, they feel that they have gained less knowl-

edge. To the extent that these assertions are true, the potential benefits of TBL (and many other active-learning strategies) will be tempered as both teachers and learners struggle with adapting to the method. In this study, we found some articles that provided very interesting initial data about potential factors connected to this issue. Gallegos and Peeters (2011) found age to be a modifier of whether students had positive or negative attitudes toward teamwork after a TBL experience (12). Masters (2012) hypothesized that cultural norms in the home country explained his findings of lower satisfaction among female students (20). We suggest that more studies are needed that specifically focus on the framing of the TBL method and the individual and social factors that shape teacher and student attitudes toward it.

While the empirical literature about team-based learning is growing rapidly, we challenge scholars to aim for high levels of rigor when studying the method. More than half of the studies in Appendix A did not include a comparison group. Of the 25 studies that used student surveys, only five employed previously validated measurement instruments (3, 6, 10, 12, 19). Only seven studies used matched pre-post assessment of learners (3, 4, 6, 12, 19, 26, 30), and only one study measured knowledge retention longer than immediately post-course [26]. Only two articles attempted to measure transfer of learning into behavioral changes in subsequent real-world performance (7, 34). In addition, whereas most articles contained adequate descriptions of four out of the seven core TBL design elements, nearly half did not describe whether peer review was used, how the incentives were structured, or how or whether immediate feedback was employed (Haidet et al., 2012). In order to fully evaluate the growing literature and make meaningful conclusions, authors need to adequately describe their methods so that readers can contextualize what was done and compare to other published experiences.

In a sense, the TBL literature is not unlike that focusing on other educational methods and technologies. We posit that now is an ideal time to be doing scholarly work with respect to TBL, because the literature is at an important maturation point. Our study shows that the method clearly has promise and that there is initial evidence for improved learning outcomes in several different domains. Many questions remain, however—for example: "What factors predict or are related to student perceptions of the method, and how do student perceptions relate to learning in TBL environments?" "How, if at all, do attitudinal changes toward working in TBL teams relate to teamwork behaviors in subsequent work settings?" "How are teacher attitudes related to the success of the method?" All of these questions move beyond the basic "Does it work?" query, and they

can help to provide evidence and stimulate conversations that will help the method to continue to evolve.

Limitations

This literature review has several limitations. Our initial search strategy was based primarily on the text term "team-based learning" in its current use and did not use earlier names for the method (such as "team learning"). This strategy, while relatively specific, did miss some earlier TBL articles that used other terms to describe the method. Our practical decision to limit to the current name of the method in our search strategy was based on limited resources to screen the considerably larger body of literature that resulted from less-specific terms.

Another limitation of our study is our own status with respect to the method. One of the authors (WM) currently serves as the president of the Team-Based Learning Collaborative, and the other two have held leadership positions in the organization. In this sense, all three of us believe in the method to some extent, limiting our scientific position of equipoise to conduct this study. In addition, because the empirical literature on TBL is still relatively young, there may be a publication bias toward articles that describe this "promising new method" and against negative studies of the method. We attempted to limit our own and the literature's bias by avoiding initial in-depth review of article results and focusing instead on whether the implementation contained all of the critical elements of TBL. The resulting 40 articles listed in Appendix A represent a current "state of the art" for studies that describe the implementation of TBL with minimal or no modification from the methods described by Michaelsen and the TBL community.

Conclusions

In conclusion, we performed a systematic, narrative review of the educational literature with respect to team-based learning and found early evidence of positive educational outcomes in terms of knowledge acquisition, participation and engagement, and team performance. TBL challenges both learners and teachers to adopt a new paradigm of education, and some find this challenge difficult. Finally, the literature is at an important maturation point, where more rigorous tests of the method and study of additional questions are needed.

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Appendix A
Content Summary of 40 Articles Focusing on Team-Based Learning

*Author(s) & Year	*Educational Context***	*Evaluation Strategy****	*Summary of Results*
[1] Anderson et al., 2011	Sophomore Baccalaureate Nursing Program	Informal observations and informal comparison of test scores with historical cohorts	Faculty and students struggled with the flipped classroom paradigm; student performance informally rated as better than historical cohorts.
[2] Anwar et al., 2012	104 2nd-year medical students; two sessions in a pathology course converted to TBL	Comparison of course semester grades with historical controls, survey of students	Eighty-eight percent of students agreed that TBL enhanced their understanding of pathology concepts; significantly fewer students had failing grades in TBL as compared to historical controls.
[3] Borges et al., 2012	105 3rd-year medical students, 36-hour internal medicine clerkship curriculum	Pre-post assessment of student emotional intelligence as related to teams and teamwork using a previously validated instrument	Students showed significant improvement in domains of awareness of own emotions, recognizing and managing others' emotions, but no change in control of own emotions.

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[4] Bou Akl et al., 2012	84 3rd- and 84 4th-year medical students, 4-session pharmacology curriculum	Comparison of pre-post knowledge and TBL assessments (e.g., RAT) and comparison of team performance between 3rd- and 4th-year students	Both sets of students showed similar knowledge gains, but 3rd-year students showed significantly higher team performance at the end of the course.
[5] Chung et al., 2009	160 1st-year medical students, 6-hour curriculum (3 sessions) in medical ethics	Description of course data (RAT and final exam grades) and unvalidated survey of students	Teams consistently outscored individuals; students in the second-lowest quartile (based on entrance GPA) showed significant improvement on final exam; students reported generally positive study and interactive behaviors.
[6] Clark et al., 2008	67 undergraduate nursing students in a lecture-based pharmacology course and 51 students in a TBL case management course	Comparison of classroom engagement dimensions; pre-post comparison of how well students valued working in teams; validated instruments used for both constructs	Students in the TBL case management course rated participation significantly higher and enjoyment lower than those in the lecture-based pharmacology course; no significant pre-post change was noted in value of teams for the TBL course.

[7] Considine et al., 2013	3-hour in-class curriculum (plus assigned advance prep work) on nurse-initiated X-ray ordering for nurses in an emergency department	Comparison of the appropriateness of a convenience sample of 300 X-ray requests between 23 RNs who participated in the curriculum and 17 RNs who did not	RNs who completed the curriculum demonstrated significantly greater documentation and appropriateness of X-ray ordering on 13 (out of 15) parameters measured.
[8] Conway et al., 2010	140 2nd-year pharmacy students per year, 18 hours of TBL activities within a 4-credit cardiovascular pharmaceutical module	Comparison of student satisfaction, test averages, grade distributions, and faculty resource utilization between the first two TBL cohorts and one historical cohort	Average test scores did not differ between TBL and the historical cohort; trends toward less students earning grades of D or F and more B grades for TBL cohorts; TBL implementation resulted in minor expenses and increases in faculty workload during the first year.
[9] Dana, 2007	Three sections of a semester-long college undergraduate junior/senior level introduction to law course; sections meet for 150 minutes/week with ~35 students per section	Comparison of student satisfaction surveys between three TBL sections and two historical cohorts that used a "modified Socratic method"; college-wide student satisfaction surveys	In a course that historically performed above the college average, TBL sections outperformed historical cohorts in terms of student perceptions of course organization, clarity, stimulation of interest, and overall effectiveness.

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[10] Drummond, 2012	Introductory engineering entrepreneurship course	Anecdotal descriptions of student participation and faculty attitudes; validated measure of critical thinking skills	Class participation and student engagement increased; one reported dimension of critical thinking improved; faculty experienced increased workload, grading complexity, and need to learn facilitation.
[11] Fujikura et al., 2013	105 4th-year medical students, 15 180-min TBL sessions; clinical medicine topics; Audience Response System used for RAP	Descriptive statistics based on surveys of students and instructors about the use of the Audience Response System	Instructors rated the utility of the Audience Response System highly; anecdotal mention is made that students rated it significantly lower.
[12] Gallegos & Peeters, 2011	58 2nd-year PharmD students, 18 hours of TBL modules on therapeutics topics within a 90-hour cardiovascular pharmacology course	Pre-post assessment of student perceptions of teamwork using a validated instrument	Older students demonstrated less positive attitudes toward teamwork after the course, while students with prior pharmacy work experience demonstrated more positive attitudes; gender and previous team experience were not associated with attitude change

[13] Grady, 2011	2nd and 3rd-year pharmacy students, a variety of Pharmacotherapeutics modules delivered using TBL	Anecdotal descriptions of instructors experiences; descriptions of course grades for the psychiatry module	In psychiatry module, average team scores were higher than average individual scores; 3/5 instructors anecdotally reported similar exam scores with TBL compared to historical cohorts, one reported a slight decrease, and one reported a slight increase.
[14] Grant-Vallone, 2010	34 college students in an upper-level TBL psychology course that met 2.5 hours per week for a full semester; 49 students in two different divisions of the same course that used cooperative learning	Comparison of group experiences between TBL and cooperative learning; comparison of group experiences in these courses compared to students' previous college group learning experiences.	TBL students less likely to report that they could have done a better job working alone; all students rated the group experiences better than the typical college group experience; several correlations were found between group process and group outcomes; formal written feedback correlated with increased responsibility and satisfaction with group work.

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[15] Inuwa et al., 2012	150 medical students in an introductory anatomy course that replaced its lecture-based portion with TBL activities	Anecdotal report of free comments and reflections on activities by learners; comparison of attendance at course TBL activities compared to laboratory sessions	Students generally appreciated TBL activities, although they felt insecure about their own anatomical knowledge since they did not receive "lectures" in the course; attendance was significantly higher at TBL sessions compared to laboratory sessions
[16] Jacobson, 2011	College students in 7 different sections (~23 students per section) of a required information literacy course	Descriptive data from an unvalidated mid-term survey of students	Quantitative data suggests that students mostly agree with statements such as "TBL contributes to learning" and "TBL provokes thinking"; qualitative comments identified the group process in response to a question about what helps students to learn

[17] Koles et al., 2010	178 2nd-year medical students in a pathology course that used a hybrid of TBL and lecture-based teaching methods	Comparison of performance on exam questions mapped to TBL sessions versus those mapped to lecture sessions	Students consistently performed higher (~5% better) on questions related to TBL sessions; much of this difference was explained by students in the highest and lowest quartiles performing disproportionately better on TBL session-related questions.
[18] Letassy et al., 2008	Approximately 130 3rd-year (in a 6-year professional program) pharmacy students in a 3-credit-hour course on applied endocrinology therapeutics	Comparison of course exam grades and student evaluation surveys between the third TBL implementation year and the last year that used lectures as the teaching strategy (historical control)	Students performed similarly or better on unit exams, and they performed better on the final examination in the TBL course, with more students earning A grades and fewer students earning failing grades; student course evaluation ratings were higher in the historical lecture-based cohort.
[19] Macke & Tapp, 2012	46 masters-level social work students in each of four sections of an introductory research course; 23 in TBL version, 23 in lecture-based or "hybrid" versions	Comparison of pre-post measures of students' intent to incorporate research into social work practice and research self-efficacy (using previously validated scales)	There was no difference between the two cohorts on intent to incorporate research into social work practice; the TBL cohort reported higher gains in research self-efficacy.

[20] Masters, 2012	108 medical students in a medical informatics course; 11 sessions used TBL during a 14-week semester	Descriptive data from a post-course survey modified from a previously published scale	Average student satisfaction ratings were high; however, females were significantly less satisfied along a number of dimensions; author hypothesizes that cultural norms regarding male-female relations in the home country may be a causal factor.
[21] McAndrew et al., 2012	1590 high school freshmen and sophomores being taught an educational module on obesity by local medical students	Unvalidated survey of high school students, open-ended queries of high school students, medical student teachers, and high school teachers	HS students rated team experiences highly. Open-ended comments demonstrated generally high levels of enthusiasm for the program from all survey participants.
[22] Nicoll-Senft, 2009	14 students in a 3-credit graduate-level course in special education	Description of course readiness assurance grades and comparison with a historical cohort that took open-book quizzes; qualitative analysis of assigned student reflection papers	Most teams outperformed individuals on RAT. Compared to the historical cohort, individual scores did not differ, while teams scored higher than the historical cohort; qualitative comments demonstrate an appreciation for the usefulness of working in teams.

[23] Nieder et al., 2005	97 1st-year medical students in a 140 contact-hour gross anatomy course that used multiple teaching modalities; 24 contact hours used TBL	Comparison of student ratings of TBL vs. other teaching components of the course; comparison of final course grades to historical cohorts (which had not received a TBL component)	Of six different teaching modalities, students rated TBL as the 3rd most helpful, closely behind dissection lab and online materials; lectures were rated lowest; TBL cohort had significantly fewer failures and less variance in final course scores, primarily due to fewer students in the low end of the grade range.
[24] Parmelee et al., 2009	180 medical students from two classes (classes of 2006 and 2007) who experienced TBL in multiple courses during their 1st and 2nd years of medical school	Description of students' responses to a unvalidated survey administered at the beginning, middle, and end of each of the first two years of medical school; comparison between 1st- and 2nd-year responses	Generally positive student responses across all domains; more positive attitudes during the 1st year in areas of professional development and satisfaction with peer evaluation; attitudes were more positive during the 2nd year for satisfaction with the team experience; there was no difference in attitudes between years for team impact on learning quality or clinical reasoning ability.

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[25] Paterson & Sneddon, 2011	Two mathematics educators had a series of conversations as one was changing mode of delivery of a final year undergraduate discrete mathematics course to TBL	Description of a variety of qualitative artifacts (notes of weekly meetings, email threads, etc.) related to conversations between the two educators	As the educators focused on trying to get students to think the way that mathematicians do, they discovered lessons learned about task construction, balance between structure and open-endedness of learning assignments, and teamwork in learning.
[26] Persky, 2012	154 2nd-year PharmD students in a 3-credit pharmacokinetics course; 15 hours devoted to 5 TBL modules	Comparison of exam scores, survey results, course evaluations, and performance in subsequent clinically applied pharmacokinetics courses between TBL course and a historical cohort that used smaller groups in a recitation-style learning format	Compared to historical controls, TBL cohort showed better exam performance, particularly on questions geared toward higher-order thinking, better performance in later coursework, and a pre-post increase in favorable attitudes toward professional behavior and teamwork.
[27] Ravindranath et al., 2010	117 3rd-year students in a psychiatry clerkship; 3 modules during the clerkship used TBL; some sessions were facilitated by trainees	Comparison of student ratings of trainee and faculty facilitators	With one exception, there were no differences in student ratings between trainee and faculty facilitators.

[28] Shellenberger et al., 2009	175 resident physicians in 8 family medicine residency programs; three 1-hr TBL "booster sessions" about patient screening and intervention for alcohol misuse	Description of logistical data, student readiness assurance data, and student responses to an evaluation survey	Attendance at booster sessions averaged approximately 50%; TRAT scores were consistently higher than IRAT scores; 75% of responders preferred the TBL format over previous didactic lectures.
[29] St. Clair & Chihara, 2012	Undergraduate liberal arts students in a semester-long statistical literacy course	Anecdotal and descriptive information based on teacher observations and student surveys	High overall satisfaction level of students and teachers ; faculty found that they could cover the content as well or better than lecturing; several typical TBL challenges were noted, e.g., initial set-up and faculty development.
[30] Tan et al., 2011	39 3rd-year medical students in two separate cohorts participating in two neurology sessions within a 9-week internal medicine clerkship	Modified crossover design in which the students cohorts were randomly assigned to a 1st session using TBL and the 2nd using lecture, and vice versa; pre-, immediate post-, and 2-day post-test scores were compared between TBL and lecture sessions	Scores increased from pre- to immediate-post for both teaching methods, but this increase was significantly higher for TBL cohort; 2-day post-test scores continued to improve with TBL and declined with lectures; effect sizes for TBL compared to lectures were highest for students in the lower-performing half of the class; the majority of students preferred TBL to lecture.

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[31] Thomas & Bowen, 2011	112 3rd-year medical students rotating (in 6 cycles) through an ambulatory care clerkship; six classroom-based sessions delivered either with TBL or with small group lectures	Experimental, unblinded crossover design; in each cycle, 3 topics were taught with TBL, remainder with lecture; topics switched in successive cycles; scores on final exam questions compared between students in TBL vs. lectures	Students who learned content through TBL outscored students who learned through lecture on 5/6 content areas; qualitative student evaluation comments focused positively on teamwork and advance preparation; negative comments focused on repeated readiness quizzes and peer review.
[32] Thomas & McPherson, 2011	Undergraduate students in a positive psychology course	Description of course evaluation data, including student evaluation scores and anecdotal comments	Student reactions to the course were positive, with evaluation scores being the highest that one of the teachers has received in 30+ years of teaching.
[33] Thomas, 2012	28 students in a semester-long undergraduate course in interpersonal communication	Qualitative and quantitative descriptive data based on student feedback and written reflections.	Quantitative data suggest relatively high engagement in class sessions; qualitative data suggest that in-class team assignments were memorable for students, and the one out-of-class group assignment was not effective.

[34] Touchet & Coon, 2005	Psychiatry resident physicians in a psychodynamic psychotherapy course	Description of learner post-course surveys and anecdotal data from supervising physicians	High course ratings, with positive open-ended comments; anecdotal stories from supervising physicians suggested that residents were integrating psychodynamic concepts into their daily work more effectively than in previous year didactic courses.
[35] Van der Putten & Vicht-Vadaken, 2010	45 masters-level public health students in a 15-week public health ethics course	Description of RAT scores, individual and team student surveys, and faculty surveys that used Rogers' Diffusion of Innovations framework	Teams consistently outscored individuals on RAT; student perceptions were generally positive, with team perceptions marginally higher than average individual perceptions; faculty scored TBL high on relative advantage, cultural compatibility, trial-ability, and visibility, and low on complexity.
[36] Walters, 2013	Pharmacy students in a medicinal chemistry course	Anecdotal description of student evaluations and teacher perceptions	Students generally found the TBL format enjoyable; teacher found preparation of course materials challenging and enjoyable.

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[37] Wiener et al., 2009	386 1st-year medical students participating in 8 parallel 3-day elective courses (12 contact hours each) within a required block course on principles of functional systems and biological regulation	Description of student responses to quantitative and qualitative program evaluation questions at the end of the courses; comparison of end-of-block exam grades between students who took an elective TBL course and those who did not	220 students completed a TBL course; TRAT scores were consistently higher than IRAT scores; student survey responses were generally positive, with females tending to score higher than males (statistically significant for one parameter); students who completed elective TBL courses scored 25% higher on the end of block exam than students who did not; 31% of TBL participants passed the final exam compared to 17% for all students.
[38] Willett et al., 2011	167 2nd-year medical students in a 5-week endocrinology and rheumatology section of a pathophysiology course, 6 case-based sessions (1.5-2.5 hours) were delivered either with TBL or small group (8-10 students) facilitated discussion	Comparison of exam scores and student satisfaction between 84 students randomly assigned to the TBL sessions and 83 students assigned to small group discussion	Exam scores were not significantly different between the two cohorts; student satisfaction was higher in the small-group learning cohort; students expressed a preference for group size <10; student answers to open-ended course surveys revealed significant dissatisfaction with case questions that were ambiguous or complex.

[39] Zgheib et al., 2011	2nd- and 4th-year medical students; one 2-hour session in 2nd year and 5 sessions in 4th year devoted to pharmacogenetics concepts/skills	Anecdotal report of student outcomes and experiences	Student satisfaction reported to be high; 2nd-year student performance reported improved on summative examinations; 4th-year student performance better on repeated questions.
[40] Zingone et al., 2010	64 3rd-year PharmD students in an ambulatory care elective delivered using TBL (37 students) or other active learning methods (27 students)	Comparison of student final exam performance, student survey results, and faculty perceptions between the two methods	Students in TBL course performed better on exams, controlling for incoming GPA; course evaluation results similar across the two teaching methods; faculty responses were generally positive, with the greatest challenges to TBL including development of team assignments, facilitation, and identification of appropriate readings.

Notes. *Numbers in brackets used in text to refer to selected articles.
**All courses used TBL as the major teaching modality, except where otherwise indicated.
***All studies were performed at a single institution.