The constituents, ideas, and trends in team-based learning: a bibliometric analysis

Javier A. Flores-Cohaila[1], Vanessa Patricia Moreno Ccama[1],
Aitana Libertad Baca Quispe[1], Alisson Micaela Lopez Ayquipa[1],
Francesca Alessandra Paz Gamarra[1],
Pierre Valentino Alfaro Peña[1] and Cesar Copaja-Corzo[2]*

[1]Universidad Cientifica del Sur, Lima, Peru, [2]Unidad de Investigacion para la Generacion y Sintesis de
Evidencias en Salud, Universidad San Ignacio de Loyola, Lima, Peru

Team-based learning (TBL) has gained significant popularity in higher education. Despite its widespread adoption, there is a lack of comprehensive understanding of the current state of TBL research. Hence, we conducted a bibliometric analysis to address this gap, reviewing 692 papers from the Web of Science database. The study revealed a notable increase in TBL research, with a peak of 87 publications in 2021. The United States emerged as the leading contributor, with medical and nursing education being the most prominent research areas. Specialized journals played a significant role in disseminating TBL research. Key themes, including TBL outcomes, non-technical competencies, and implementation principles, were identified. Moreover, it highlighted a growing interest in applying TBL in interprofessional education and formative assessment. The findings suggest the need to establish priorities and expand TBL research beyond health professions education to other fields. This study provides valuable insights into the current landscape of TBL research and offers directions for future investigations.

KEYWORDS

active learning, team-based learning, higher education, health professions education, Bibliometrics

Introduction

Team-based learning (TBL) is an active teaching-learning method that has gained attention in the last decade. Developed in 1970 by Larry Michaelsen in business education, it has been rapidly adopted in other fields, such as health professions education (HPE) (Haidet et al., 2012). It allows students to apply knowledge through structured and systematic activities. Hence, TBL consists of several steps. It begins with individual preparation followed by an individual readiness assurance test (iRAT) in class, then a team readiness assurance test (tRAT), and work on application exercises for problem-solving, followed by immediate feedback (Burgess and Matar, 2020). Through this rigorous methodology, evidence has proven its positive impact on teamwork, problem-solving, and communication skills (Sisk, 2011; Swanson et al., 2019).

While extensively studied, the research on TBL needs to be more cohesive. Previous reviews synthesized TBL research. Thus far, reviews have explored its use in HPE and business education (Sisk, 2011), developing TBL guidelines for HPE (Haidet et al., 2012; Parmelee et al.,

2012; Parmelee and Michaelsen, 2010), and evaluating HPE interventions based on those guidelines (Burgess et al., 2014). However, these reviews have mostly covered the field of HPE (Burton et al., 2024; Swanson et al., 2019). Thus far, no review has established the TBL landscape or explored its constituents, such as its growth or themes.

A similar phenomenon has been seen with research in other active methodologies, such as problem-based learning and flipped classrooms. However, previous researchers have conducted bibliometric analyses to identify gaps and map their current state (Zhang et al., 2022, 2024).

Building on the authors' efforts described above, we decided to conduct this study. Here, we aimed to conduct a bibliometric analysis of TBL research to explore key characteristics of the field, its intellectual structure, and emerging themes. The findings of this study will provide valuable insights and guidance for researchers, educators, and policymakers interested in advancing TBL research and practice.

Methods

We conducted a bibliometric study in accordance with the recommendations of Öztürk et al. (2024) and with the PRISMA Extension for Scoping Reviews statement (Tricco et al., 2018) to enhance reproducibility. Bibliometric studies fall under the literature review studies, which employ quantitative methods to analyze bibliometric data, providing insights into a research field (Donthu et al., 2021). Although bibliometric studies are common, the major limitation was the need for a standardized methodology. We decided to adhere to the methodological guidelines described above to overcome this limitation due to its practicality and novelty. Öztürk et al. (2024) recommend following a four-step approach that defines the research aim, data collection, data analysis, and interpretation of findings. Lastly, bibliometric studies most resemble scoping reviews due to their comprehensive coverage, so we adhered to the PRISMA guidelines.

Research questions

This bibliometric was developed to answer the following research questions:

RQ1: What are the key characteristics of the TBL research field (e.g., number of publications, annual growth rate, research areas, citation topics)?

RQ2: Which countries have contributed the most to TBL research in terms of author affiliations and corresponding authors?

RQ3: Which journals have published the most papers on TBL, and how do they relate to different fields of education (e.g., medical, nursing, pharmacy)?

RQ4: What are the most impactful studies in the field of TBL based on local citation scores, and what are their main focuses?

RQ5: What is the conceptual structure in TBL research, as revealed by keyword co-occurrence analysis?

RQ6: How does the intellectual structure of TBL research, as determined by co-citation analysis, reflect the focus on specific research topics?

RQ7: What are the emerging trends and themes in recent TBL research from 2019 to 2023, as identified through bibliographic coupling analysis?

Data collection

The Web of Science (WoS) database was chosen for this bibliometric research. WoS has long been the most comprehensive citation data source worldwide (Birkle et al., 2020) and is commonly used for bibliometric studies (Liu and He, 2023). Furthermore, it provides richer metadata (Kokol, 2023). Hence, it was preferred over other databases such as Scopus or Pubmed.

To develop the search strategy, we followed a three-step approach. First, key research studies were identified in PubMed. Second, the PMIDs of these studies were extracted and imported into YaleMESH Analyzer, where key terms for the final search strategy were identified. Third, with the identified terms, the search strategy for the WoS was developed. The search strategy used was TS = ("Team-based learning"). The following filters were applied in the WoS database: Publication until December 2023, articles and reviews, English language, and indexed on the Science Citation Index Expanded (SCI-EXPANDED) or Social Sciences Citation Index (SSCI) or Emerging Sources Citation Index (ESCI).

Retrieved studies were downloaded and screened to enhance specificity. Two authors independently reviewed each study title and abstract to assess if they were studies on team-based learning and were conducted in higher education. In case of discrepancies, they were solved with a third author. The list of eligible studies was searched and downloaded from the WoS database, using their unique ID. The eligible studies were downloaded in a text file with complete information and cited references for analysis. The full selection process is shown in Figure 1.

Data analysis

Data analysis was conducted using performance analysis and scientometric mapping. Performance analysis employs descriptive statistics to evaluate the dataset using bibliometric indicators (Donthu et al., 2021). Meanwhile, scientometric mapping employs advanced methods to identify social, intellectual, or conceptual structures and the evolution of a research field (Donthu et al., 2021).

The performance analysis was conducted using the biblioshiny app from the bibliometrix package in RStudio (Aria and Cuccurullo, 2017) and the WoS analyzer. The scientometric mapping approach used VosViewer software (Van Eck and Waltman, 2010). All analyses were performed using fractal counting, superior to complete counting methods for developing networks (Batagelj, 2020; Perianes-Rodriguez et al., 2016).

Data interpretation

We followed the sensemaking approach for data interpretation (Lim and Kumar, 2024). This was performed to understand the intellectual and conceptual structures and emerging trends.

FIGURE 1
The selection process for this study.
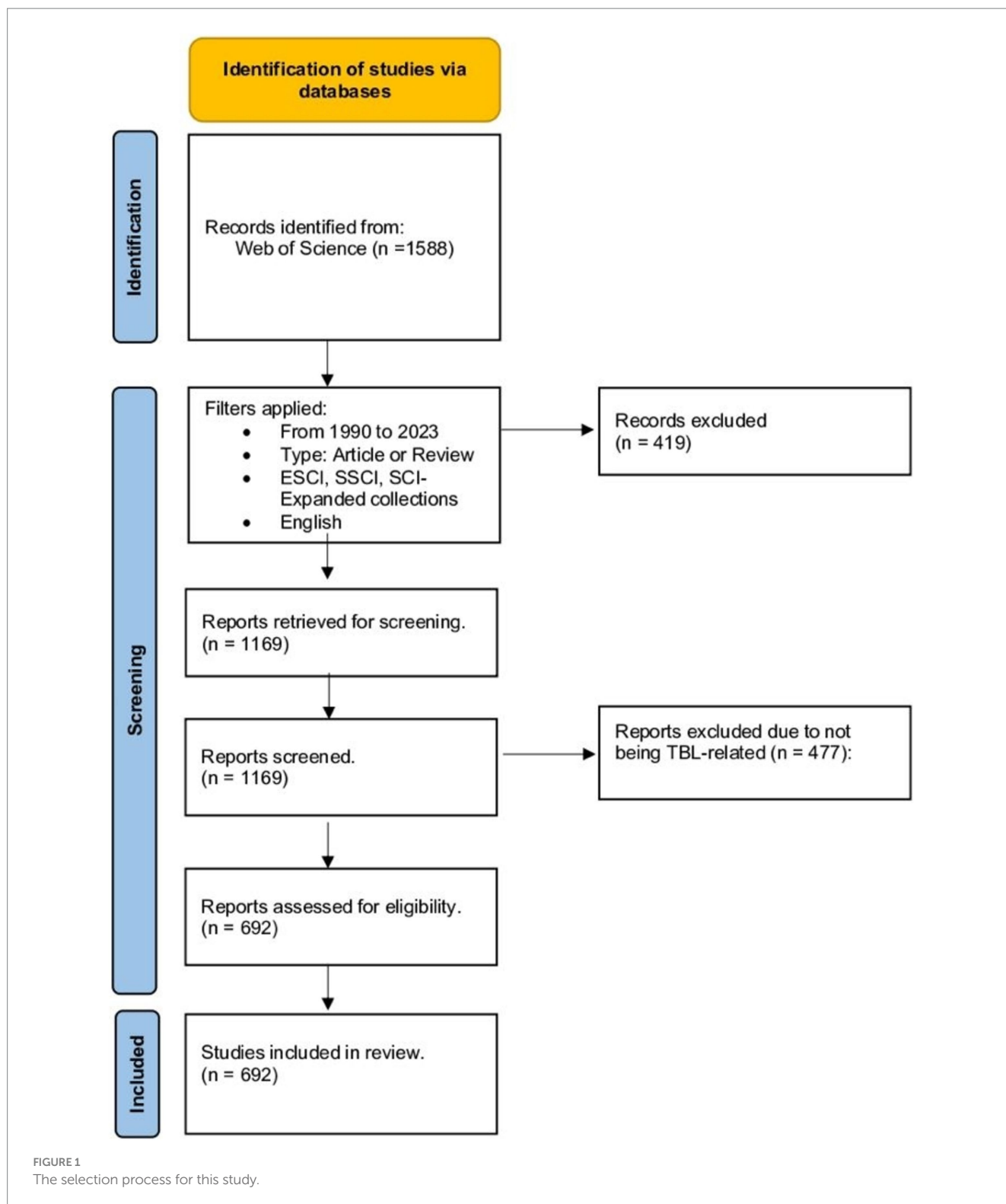
Results

The field at a glance

Key indicators from the field of TBL are shown in Figure 2. There were 692 publications by 2,291 authors across 268 journals. The year with the most publications was 2021 ($n = 87$), while the year with the least was 2005 ($n = 3$). Moreover, there was an annual growth of 17.54%. The countries with the most authors were the United States ($n = 827$), followed by China ($n = 158$) and Australia ($n = 126$). Similarly, when analyzing countries with the most corresponding authors, they were the same: the United States with 326 publications, China with 56, and Australia with 47.
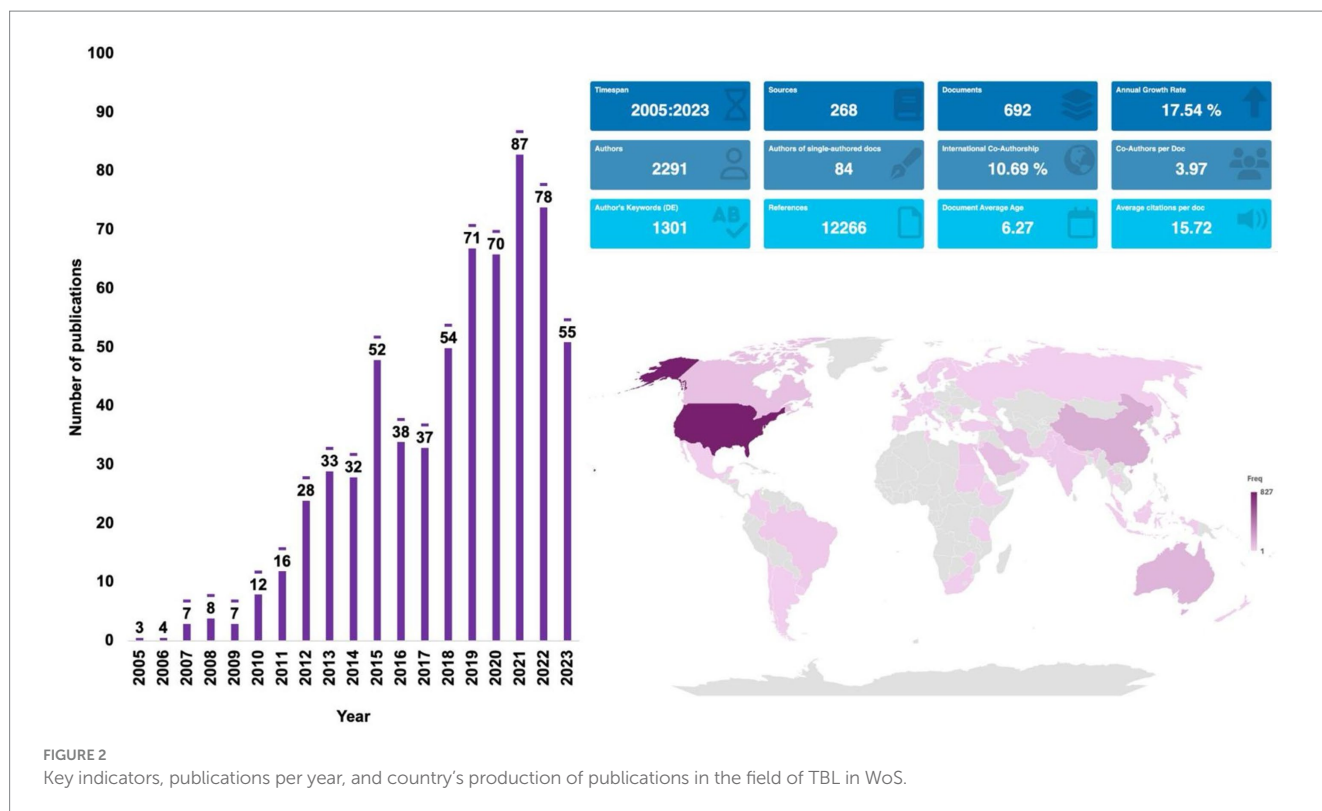
FIGURE 2
Key indicators, publications per year, and country's production of publications in the field of TBL in WoS.

Areas of research and journals

To identify which research field has contributed the most to TBL, the research areas and citations topics micro were analyzed. In the research area, the most frequent was Education Educational Research (n = 449, 64.42%) followed by Nursing (n = 73, 10.47%), Health Care Sciences Services (n = 63, 9.04%), Pharmacology (n = 54, 7.75%) and General Internal Medicine (n = 46, 6.60%). While for citations topics micro, the most common was medical education (n = 448, 64.28%), followed by self-regulated learning (n = 70, 10.04%), interprofessional education (n = 29, 4.16%), Nursing Education (n = 25, 3.59%) and Science Education (n = 11, 1.58%). Hence, the most contributing field was health professions education.

Figure 3 depicts the journals with the most publications and a bibliographic coupling of the 25 most relevant journals in the field. Regarding journals with most publications, all were from the health professions education realm, most from medical education, followed by nursing and pharmacy education. Moreover, most journals began publishing TBL studies in 2007. Similar findings were shown in the bibliographic coupling in Figure 3, where three clusters are shown. Cluster 1 (red) is characterized mainly by medical, pharmacy, and dental education journals, while Cluster 2 (green) by nursing education journals and cluster 3 (blue) by other fields journals. Hence, most of the scholarly conversation related to TBL occurs in health professions education journals.

Conceptual and intellectual structure

The most impactful studies based on local citations are portrayed in Table 1 to delineate the most important ideas in the field. These studies were published between 2004 and 2013, and the total local citations (TLC) ranged from 64 to 150. All the most impactful studies were published in the realm of HPE. Five were primary studies focused on academic outcomes (Clark et al., 2008; Koles et al., 2010; Nieder et al., 2005; Zgheib et al., 2010) and barriers and enablers (Thompson et al., 2007) for TBL. The remaining were secondary studies, with two reviews assessing the effectiveness of TBL (Fatmi et al., 2013; Sisk, 2011), two guides on implementation (Parmelee et al., 2012; Parmelee and Michaelsen, 2010), and one review proposing a theoretical basis for TBL (Hrynchak and Batty, 2012). Hence, the most important ideas emerged from HPE and are yielded in the basis and effectiveness of TBL.

Total local citations

The conceptual structure and the intellectual structure are delimited in Figure 4. Eight clusters were found in the keyword co-occurrence analysis. Cluster 1 (Red) was on "outcomes of team-based learning," covering keywords such as perception, satisfaction, knowledge, and performance, which are in the spectrum of the Kirkpatrick framework. The Kirkpatrick framework is an evaluation model used to measure the effectiveness of training programs. It is divided into four levels: (1) Reaction, which assesses participant satisfaction; (2) Learning, which measures how much they have learned; (3) Behavior, which analyzes if they apply what they have learned in practice; and (4) Results, which examines the long-term impact on performance or organizational goals.

Cluster 2 (green) covered "non-technical competencies in team-based learning" with keywords such as teamwork, collaboration, and communication. Cluster 3 (blue) covered "principles of team-based

| Rank	Journal	H-Index	Total Citations	Number of publications	First publication
1	BMC Medical Education	17	757	41	2011
2	Current in Pharmacy Teaching and Learning	13	354	39	2011
3	American Journal Of Pharmaceutical Education	21	1180	37	2008
4	Medical Science Educator	4	59	33	2019
5	Medical Teacher	18	1565	28	2009
6	Nurse Education Today	9	380	18	2013
7	Advances In Physiology Education	9	297	13	2007
8	Journal Of Educational Evaluation For Health Professions	7	142	13	2008
9	Nurse Educator	8	223	12	2012
10	Anatomical Sciences Education	11	719	11	2008
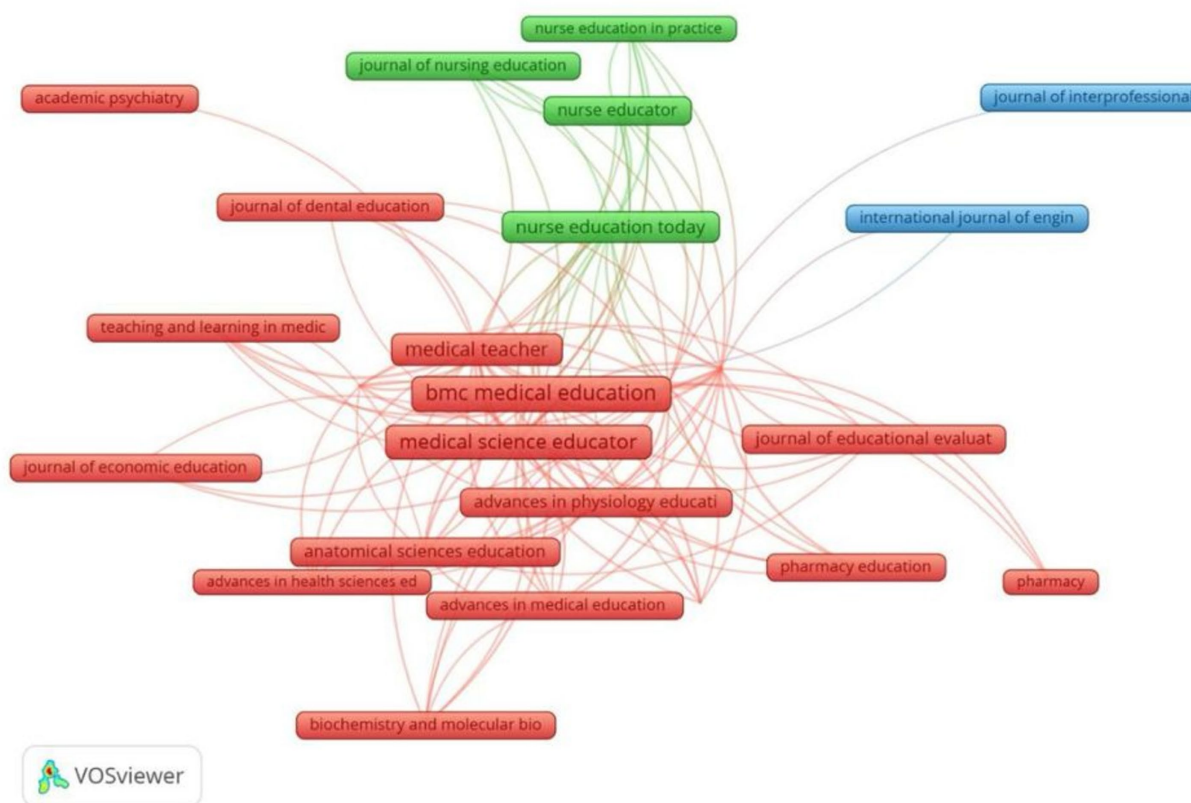
FIGURE 3
Descriptive and network analysis of the most important journals in TBL.

learning" with keywords such as active learning, collaborative learning, online learning, problem-based learning, and flipped classroom. Cluster 4 (yellow) was on "pharmacy and nursing education." Cluster 5 (purple) was on "anatomy education." Cluster 6 (light blue) was on "COVID-19 and online team-based learning." Cluster 7 (orange) was on "faculty development for team-based learning."

Figure 4 shows the intellectual structure through a co-citation analysis of the top 30 most cited references. Two clusters are shown. Cluster 1 (red) delves into the impact of TBL through empirical data for interventions and qualitative studies. Cluster 2 (green) comprises studies that delve into the fundamentals of implementing TBL and its effectiveness through reviews.

Emerging themes

A bibliographic coupling analysis on studies published between 2019 and 2023 was conducted and shown in Figure 5 to visualize

TABLE 1 Top 10 most locally cited studies in the field of TBL.

| Rank	Title	Author, year	TLC	Summary
1	Team-based learning: A practical guide: AMEE guide no. 65	Parmelee et al. (2012)	150	Practical guidelines for the implementation of TBL in health professions education.
2	The impact of team-based learning on medical students' academic performance	Koles et al. (2010)	128	This retrospective analysis shows that TBL benefits low-performing medical students' academic achievement.
3	Team-based learning in a medical gross anatomy and embryology course	Nieder et al. (2005)	107	This is a descriptive study that shows that TBL is perceived as adequate by medical students and faculty for teaching anatomy and embryology.
4	The effectiveness of team-based learning on learning outcomes in health professions education: BEME Guide No. 30	Fatmi et al. (2013)	93	This systematic review shows no inferiority of TBL against traditional methods with academic achievement as an outcome in health professions education.
5	Team-based learning at 10 medical schools: 2 years later	Thompson et al. (2007)	91	A long-term follow-up of 10 years on different medical schools that offer advantages and barriers for TBL implementation.
6	Twelve tips for doing effective Team-Based Learning (TBL)	Parmelee and Michaelsen (2010)	89	Practical review for educators interested in TBL. It provides practical advice for the effective implementation of TBL.
7	Team-based learning: systematic research review	Sisk (2011)	79	Systematic review of TBL studies in various disciplines shows varied results, but TBL is demonstrated as a non-inferior alternative to other educational methods.
8	The educational theory basis of team-based learning	Hrynchak and Batty (2012)	75	Theoretical review for educators in the field of medical education establishes the theoretical foundation of TBL in constructivist theories.
9	Team-based learning in an undergraduate nursing course	Clark et al. (2008)	74	Intervention study in nursing students. It demonstrated that implementing TBL in a nursing course significantly improves student engagement and performance.
10	Using team-based learning to teach pharmacology to second year medical students improves student performance	Zgheib et al. (2010)	64	Intervention study. In second-year medical students in pharmacology. It demonstrated that TBL is accepted by students and shows results comparable to traditional methods.
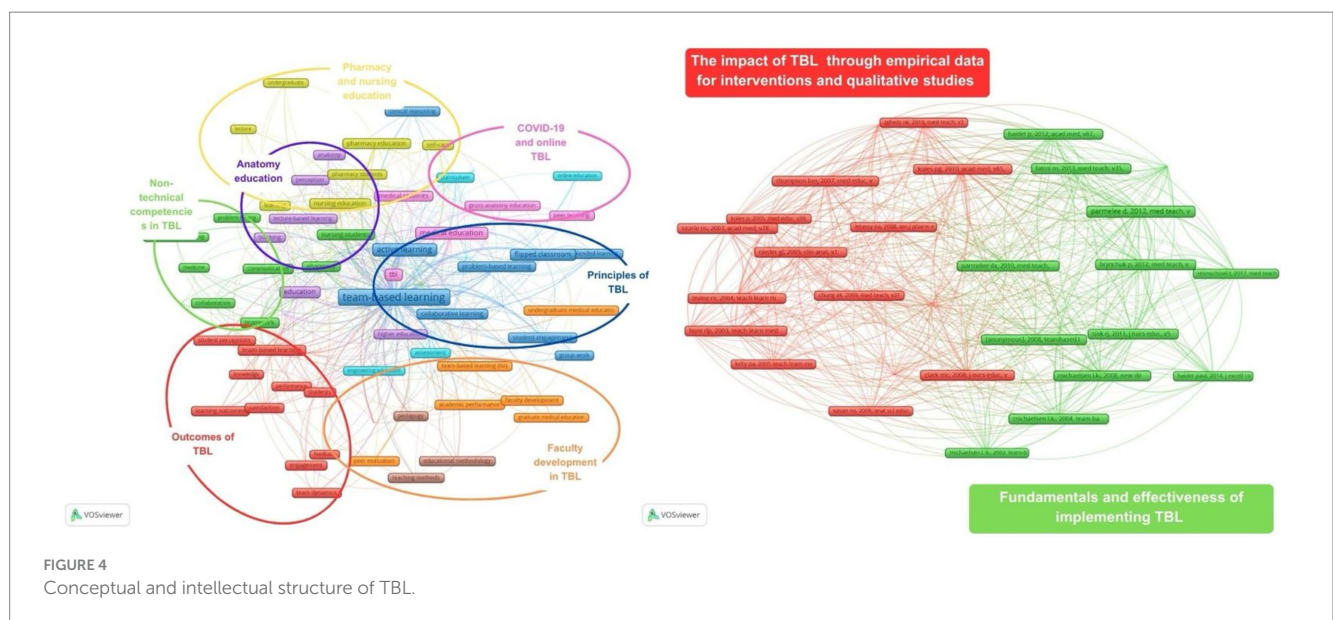
FIGURE 4
Conceptual and intellectual structure of TBL.

emerging trends. Eight clusters were analyzed. Cluster 1 (red) delves into two major topics. The first is the employment of TBL in areas such as neuroanatomy-neuroradiology, ultrasound skills, and ethics in medical education. While the second focuses on the implementation of online TBL in medical education (Cevik et al., 2019; Cremerius et al., 2021; Rezende et al., 2020; Smeby et al., 2020). Cluster 2 (green) covers studies that delved into the employment of flipped classrooms

with TBL in HPE, with most being primary studies (Kang and Kim, 2021; Wilson et al., 2019).

Cluster 3 (blue) and cluster 8 (brown) comprised studies on collaboration and interprofessionalism in TBL (Burgess et al., 2020b; Lochner et al., 2020; Walker et al., 2020).

Cluster 4 (yellow) comprises two subclusters. The first, in the center, delves into studies on TBL in higher education in computer
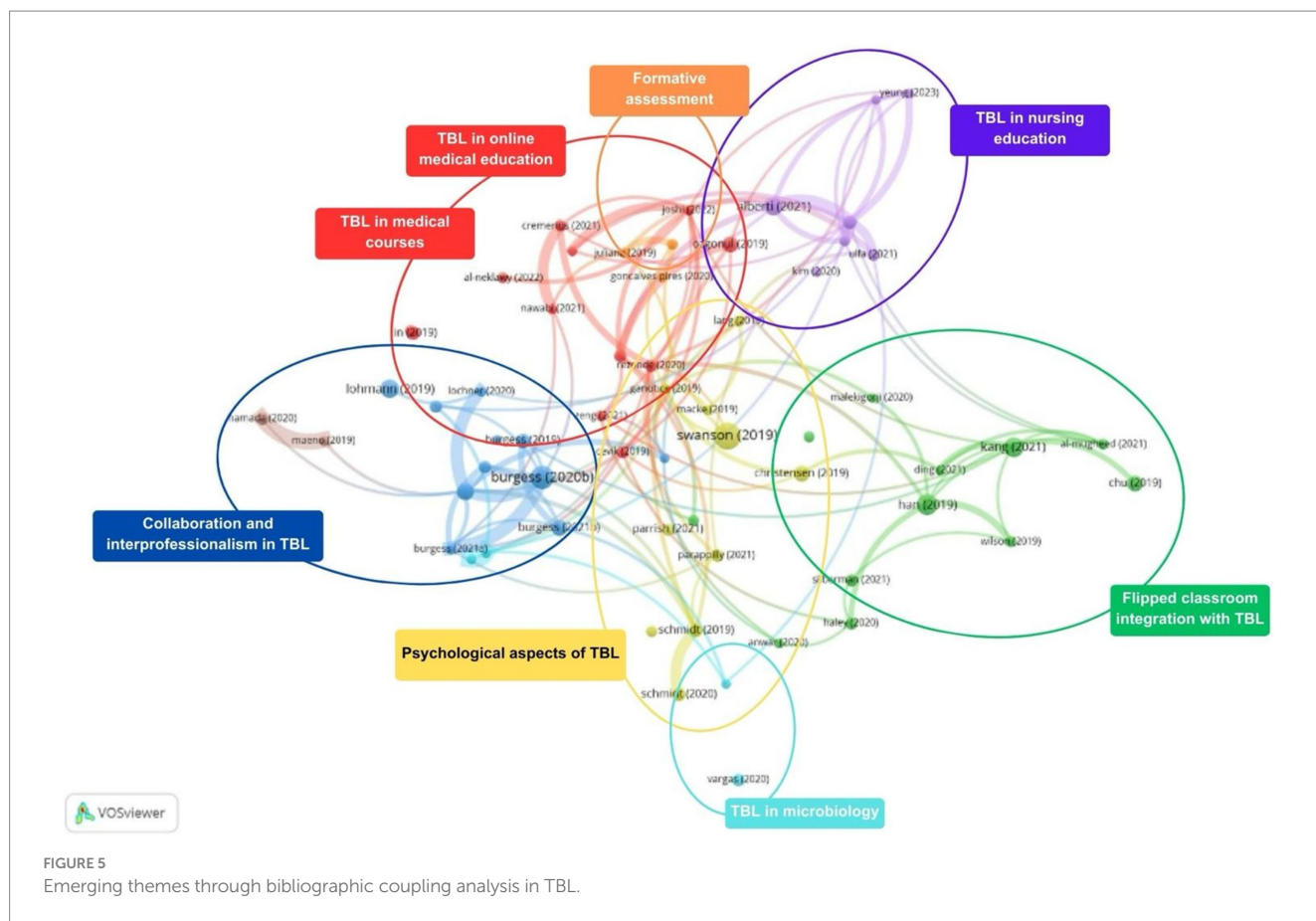
FIGURE 5
Emerging themes through bibliographic coupling analysis in TBL.

science and accountability (Christensen et al., 2019; Swanson et al., 2019). The second at the bottom covers TBL's psychological aspects in HPE (Schmidt et al., 2019).

Cluster 5 (purple) delves into studies conducted in nursing education, with systematic reviews and randomized controlled trials showing the field's advancement. In addition to one study, we employed TBL with simulation training and the other TBL for electrocardiography training for intensive care nurses (Alberti et al., 2021; Considine et al., 2021; Yeung et al., 2023).

Cluster 6 (light blue) is only represented by studies from one author and covers the implementation of TBL in microbiology and infectious disease courses (Carrasco et al., 2019). Cluster 7 (orange) comprises studies on the impact of formative assessment with TBL, showing promising directions while exploring factors that enhance deep approaches to learning in TBL (Mogali et al., 2020; Pires et al., 2020).

Discussion

Here, we conducted a bibliometric analysis on the research field of TBL in the WoS database from 2005 to 2023. Our major findings are as follows: (1) While there has been a major growth in the field, most publications are from a selected group of countries leaded by the United States; (2) The field that contributed the most to TBL research has been health professions education; (3) The conceptual structure shows that outcomes, non-technical competencies, online TBL, principles of TBL and HPE are the constituent topics; (4) The intellectual structure revealed that the main focus of the field were the

effectiveness of TBL and on how and why to implement TBL; and (5) Emerging themes across clusters were the employment of TBL to interprofessional education, its use for skills acquisition, the change toward formative assessment in TBL, and its expansion toward fields aside from HPE such as computer science and accountability.

Strengths and limitations

While our bibliometric study adheres to good practices such as reporting guidelines, published framework and triangulation of findings, it is still a victim of some limitations. Although previous studies have provided evidence that using only one database, such as the Web of Science, is non-inferior to multiple databases, it may still pose a limitation. This may lead to the exclusion of some studies, as we believe that current TBL innovations are not being published in peer-reviewed sources. Hence, although our findings provide a broad landscape of the research field, further studies may be needed, including other databases such as Scopus or PubMed. The overrepresentation of HPE in the TBL field affects our findings' generalizability to different fields such as law, economics, or engineering education. Hence, it is essential to take this into notice.

Interpretation of findings

Several reasons can explain the growth in TBL research. First, due to the increase in student to faculty ratio worldwide (Buckner and
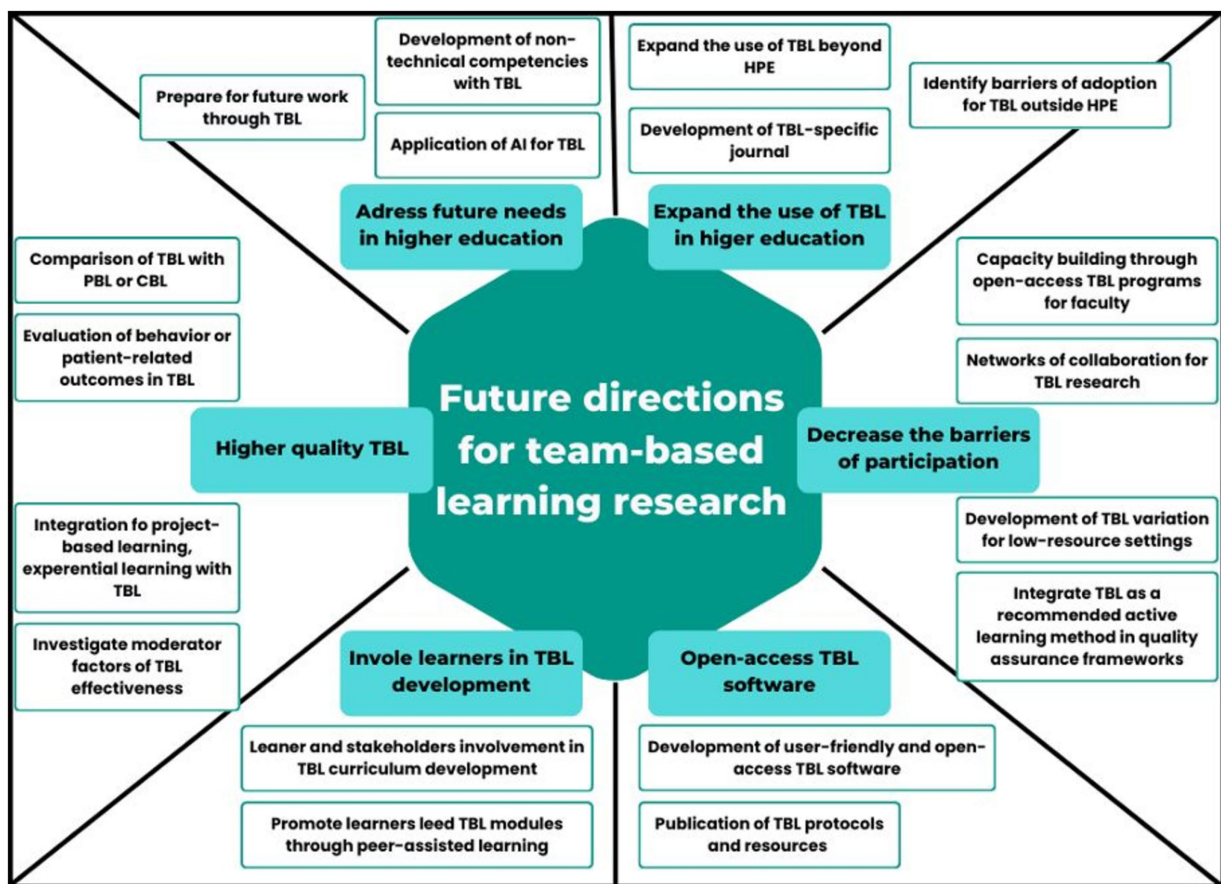
FIGURE 6
Recommendations for future research.

Zhang, 2021), TBL poses as a solution for large classrooms with acceptable outcomes in engagement and academic achievement (Fatmi et al., 2013; Parmelee et al., 2012). Second, there is a need to develop non-technical skills in higher education students due to changing dynamics in the current world. TBL has the most evidence in its favor among potential teaching methods for this endeavor. Third, higher education is undergoing a significant shift toward active learning methods. This transition is driven by the recognition that traditional lecture-based instruction may not always be effective in engagement or academic achievement. Hence, problem-based learning, peer instruction, and TBL have been adopted rapidly (Parmelee et al., 2020).

Our findings show that most research has been conducted in HPE. This is in accordance with a systematic review of TBL in higher education, where most of the studies were in medical education (Swanson et al., 2019). In addition, this has been similar in previous bibliometric studies on Problem-Based Learning and Flipped Classroom (FC) (Zhang et al., 2022, 2024). This may be explained due to the position of HPE as a discipline with an extensive output (Blouin, 2022; Maggio et al., 2022). Another explanation of the extensive protagonism of HPE may be that TBL can be understood as an extension of PBL, and PBL emerged in the field of HPE (Neville et al., 2019). While this represents an advance for HPE, it points out the need for further research on TBL from other disciplines.

The intellectual and conceptual structure can be understood as a process with well-developed roots. A considerable body of evidence suggests its non-inferiority to other traditional methods in technical and non-technical outcomes (Chen et al., 2018; Swanson et al., 2019). However, except for one systematic review, no other review has compared TBL versus other active methods, such as case or problem-based learning (Xiao et al., 2023). Moreover, authors have suggested that it is well-rooted on constructivist theories (Hrynchak and Batty, 2012). Furthermore, there are guides on how to conduct TBL (Burgess et al., 2020a; Parmelee and Michaelsen, 2010) and on how to report research on TBL (Haidet et al., 2012). This is reflected in developing the TBL-Collaborative[1] with events, conferences, and funding opportunities. Hence, it suggests that the field of TBL is past its early stages.

Emerging field themes align with current research trends in higher and health professions education. For example, interprofessional education has been declared as a priority in training for healthcare students (Bogossian et al., 2023; Buring et al., 2009). While there would be no collaboration between professions in a normal preclinical curriculum, TBL can surpass this limitation (Buhse and Della Ratta, 2017). Several research supports that TBL can create

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1   https://www.teambasedlearning.org/

spaces where preclinical students can collaborate. Furthermore, these studies have reported favorable outcomes and experiences (Burgess et al., 2020b; Ho et al., 2022).

There was a shift from cognitive knowledge acquisition to skills such as electrocardiography interpretation, patient care, and history taking (Fernandes et al., 2019; Kang et al., 2016; Kim and Kim, 2020). While this was only seen in HPE, it reflects the adoption of competency-based education and the employment of experiential learning with TBL. As the field evolves, it is expected that experiential learning will be more integrated with TBL hence guides will be needed. Furthermore, the complexity of real cases with simulation or standardized patients is more authentic and complex for the application exercises section than just multiple-choice questions.

Implications and future directions

To our knowledge, this is the first bibliometrics on TBL. Hence, it serves as a starting point to identify where we are at and where we should go. Currently, there are no research priorities for TBL. Hence, the recommendations for future direction would be based on the interpretation of findings and the Pathways to 2050 and beyond document published by UNESCO (2021). The set of recommendations is shown in Figure 6.

Six directions are suggested. However, we believe that the most important direction worldwide would be the development of research priorities for TBL. Previous exercises have been conducted in HPE with adequate results (Ajjawi et al., 2017; Ball et al., 2016). In the meantime, we recommend researchers to follow our proposed directions.

Conclusion

This study provides a broad overview of the research field of TBL. The findings reveal a growth, with the United States leading the publication output and HPE being the main contributor. Key topics in the field are TBL effectiveness in acquiring technical and non-technical competencies, and how to implement TBL. Emerging themes include the application of TBL in interprofessional education, skills acquisition, and formative assessment. Despite limitations, this study serves as a starting point for identifying TBL research's current state and future directions. We recommend that major institutions develop a set of research priorities. However, in the meantime, we proposed six directions for further TBL research such as the expansion of TBL beyond HPE, the decrease of barriers of participation with capacity building and development of TBL-variation, the development of open-access TBL software,

involvement of learners in TBL development, compare TBL with active methods, and address future needs such as AI in TBL research.

Author contributions

JF-C: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. VM: Data curation, Investigation, Validation, Writing – original draft, Writing – review & editing. AB: Data curation, Investigation, Validation, Writing – original draft, Writing – review & editing. AL: Data curation, Investigation, Validation, Writing – original draft, Writing – review & editing. FP: Data curation, Investigation, Validation, Writing – original draft, Writing – review & editing. PA: Data curation, Investigation, Project administration, Validation, Writing – original draft, Writing – review & editing. CC-C: Data curation, Funding acquisition, Investigation, Methodology, Validation, Writing – original draft, Writing – review & editing.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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References

Ajjawi, R., Barton, K. L., Dennis, A. A., and Rees, C. E. (2017). Developing a national dental education research strategy: priorities, barriers and enablers. *BMJ Open* 7:e013129. doi: 10.1136/bmjopen-2016-013129

Alberti, S., Motta, P., Ferri, P., and Bonetti, L. (2021). The effectiveness of team-based learning in nursing education: a systematic review. *Nurse Educ. Today* 97:104721. doi: 10.1016/j.nedt.2020.104721

Aria, M., and Cuccurullo, C. (2017). Bibliometrix: an R-tool for comprehensive science mapping analysis. *J. Informet.* 11, 959–975. doi: 10.1016/j.joi.2017.08.007

Ball, L., Barnes, K., Laur, C., Crowley, J., and Ray, S. (2016). Setting priorities for research in medical nutrition education: an international approach. *BMJ Open* 6:e013241. doi: 10.1136/bmjopen-2016-013241

Batagelj, V. (2020). On fractional approach to analysis of linked networks. *Scientometrics* 123, 621–633. doi: 10.1007/s11192-020-03383-y

Birkle, C., Pendlebury, D. A., Schnell, J., and Adams, J. (2020). Web of science as a data source for research on scientific and scholarly activity. *Quantitative Sci. Stu.* 1, 363–376. doi: 10.1162/qss_a_00018

Blouin, D. (2022). Health professions education as a discipline: evidence based on Krishnan's framework. *Med. Teach.* 44, 445–449. doi: 10.1080/0142159X.2021.2020233

Bogossian, F., New, K., George, K., Barr, N., Dodd, N., Hamilton, A. L., et al. (2023). The implementation of interprofessional education: a scoping review. *Adv. Health Sci. Educ.* 28, 243–277. doi: 10.1007/s10459-022-10128-4

Buckner, E., and Zhang, Y. (2021). The quantity-quality tradeoff: a cross-national, longitudinal analysis of national student-faculty ratios in higher education. *High. Educ.* 82, 39–60. doi: 10.1007/s10734-020-00621-3

Buhse, M., and Della Ratta, C. (2017). Enhancing interprofessional education with team-based learning. *Nurse Educ.* 42, 240–244. doi: 10.1097/NNE.0000000000000370

Burgess, A., Kalman, E., Haq, I., Leaver, A., Roberts, C., and Bleasel, J. (2020b). Interprofessional team-based learning (TBL): how do students engage? *BMC Med. Educ.* 20:118. doi: 10.1186/s12909-020-02024-5

Burgess, A., and Matar, E. (2020). "Team-based learning (TBL): theory, planning, practice, and implementation" in Clinical Education for the Health Professions: Theory and Practice. eds. D. Nestel, G. Reedy, L. McKenna and S. Gough (Cham: Springer), 1–29. doi: 10.1007/978-981-13-6106-7_128-1

Burgess, A. W., McGregor, D. M., and Mellis, C. M. (2014). Applying established guidelines to team-based learning programs in medical schools: a systematic review. *Acad. Med.* 89, 678–688. doi: 10.1097/ACM.0000000000000162

Burgess, A., van Diggele, C., Roberts, C., and Mellis, C. (2020a). Team-based learning: design, facilitation and participation. *BMC Med. Educ.* 20:461. doi: 10.1186/s12909-020-02287-y

Buring, S. M., Bhushan, A., Broeseker, A., Conway, S., Duncan-Hewitt, W., Hansen, L., et al. (2009). Interprofessional education: definitions, student competencies, and guidelines for implementation. *Am. J. Pharm. Educ.* 73:59. doi: 10.1016/S0002-9459(24)00554-0

Burton, R., Kellett, U., Mansah, M., and Sriram, D. (2024). A systematic review of online team based learning approaches in health professional education. *Nurse Educ. Today* 138:106156. doi: 10.1016/j.nedt.2024.106156

Carrasco, G. A., Behling, K. C., and Lopez, O. J. (2019). A novel grading strategy for team-based learning exercises in a hands-on course in molecular biology for senior undergraduate underrepresented students in medicine resulted in stronger student performance. *Biochem. Mol. Biol. Educ.* 47, 115–123. doi: 10.1002/bmb.21200

Cevik, A. A., ElZubeir, M., Abu-Zidan, F. M., and Shaban, S. (2019). Team-based learning improves knowledge and retention in an emergency medicine clerkship. *Int. J. Emerg. Med.* 12:6. doi: 10.1186/s12245-019-0222-2

Chen, M., Ni, C., Hu, Y., Wang, M., Liu, L., Ji, X., et al. (2018). Meta-analysis on the effectiveness of team-based learning on medical education in China. *BMC Med. Educ.* 18:77. doi: 10.1186/s12909-018-1179-1

Christensen, J., Harrison, J. L., Hollindale, J., and Wood, K. (2019). Implementing team-based learning (TBL) in accounting courses. *Acc. Educ.* 28, 195–219. doi: 10.1080/09639284.2018.1535986

Clark, M. C., Nguyen, H. T., Bray, C., and Levine, R. E. (2008). Team-based learning in an undergraduate nursing course. *J. Nurs. Educ.* 47, 111–116. doi: 10.3928/01484834-20080301-02

Considine, J., Berry, D., Allen, J., Hewitt, N., Oldland, E., Sprogis, S. K., et al. (2021). Team-based learning in nursing education: a scoping review. *J. Clin. Nurs.* 30, 903–917. doi: 10.1111/jocn.15599

Cremerius, C., Gradl-Dietsch, G., Beeres, F. J. P., Link, B.-C., Hitpaß, L., Nebelung, S., et al. (2021). Team-based learning for teaching musculoskeletal ultrasound skills: a prospective randomised trial. *Eur. J. Trauma Emerg. Surg.* 47, 1189–1199. doi: 10.1007/s00068-019-01298-9

Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., and Lim, W. M. (2021). How to conduct a bibliometric analysis: an overview and guidelines. *J. Bus. Res.* 133, 285–296. doi: 10.1016/j.jbusres.2021.04.070

Fatmi, M., Hartling, L., Hillier, T., Campbell, S., and Oswald, A. E. (2013). The effectiveness of team-based learning on learning outcomes in health professions education: BEME guide no. 30. *Med. Teach.* 35, e1608–e1624. doi: 10.3109/0142159X.2013.849802

Fernandes, A. K., Ecklar, P., Rundell, K., Luster, G., and Cavalcanti, M. (2019). Integrating simulated patients in TBL: a strategy for success in medical education. *Med. Sci. Educ.* 29, 383–387. doi: 10.1007/s40670-019-00727-z

Haidet, P., Levine, R. E., Parmelee, D. X., Crow, S., Kennedy, F., Kelly, P. A., et al. (2012). Perspective. *Acad. Med. J. Assoc. Am. Med. Colleges* 87, 292–299. doi: 10.1097/ACM.0b013e318244759e

Ho, J. M.-C., Wong, A. Y.-L., Schoeb, V., Chan, A. S.-W., Tang, P. M.-K., and Wong, F. K.-Y. (2022). Interprofessional team-based learning: a qualitative study on the experiences of nursing and physiotherapy students. *Front. Public Health* 9:706346. doi: 10.3389/fpubh.2021.706346

Hrynchak, P., and Batty, H. (2012). The educational theory basis of team-based learning. *Med. Teach.* 34, 796–801. doi: 10.3109/0142159X.2012.687120

Kang, H. Y., and Kim, H. R. (2021). Impact of blended learning on learning outcomes in the public healthcare education course: a review of flipped classroom with team-based learning. *BMC Med. Educ.* 21:78. doi: 10.1186/s12909-021-02508-y

Kang, K.-A., Kim, S.-J., Oh, J., Kim, S., and Lee, M.-N. (2016). Effectiveness of simulation with team-based learning in newborn nursing care. *Nurs. Health Sci.* 18, 262–269. doi: 10.1111/nhs.12245

Kim, S., and Kim, C.-G. (2020). Effects of an electrocardiography training program: team-based learning for early-stage intensive care unit nurses. *J. Contin. Educ. Nurs.* 51, 174–180. doi: 10.3928/00220124-20200317-07

Kokol, P. (2023). Discrepancies among Scopus and web of science, coverage of funding information in medical journal articles: a follow-up study. *J. Med. Libr. Assoc.* 111, 703–708. doi: 10.5195/jmla.2023.1513

Koles, P. G., Stolfi, A., Borges, N. J., Nelson, S., and Parmelee, D. X. (2010). The impact of team-based learning on medical Students' academic performance. *Acad. Med.* 85, 1739–1745. doi: 10.1097/ACM.0b013e3181f52bed

Lim, W. M., and Kumar, S. (2024). Guidelines for interpreting the results of bibliometric analysis: a sense making approach. *Glob. Bus. Organ. Excell.* 43, 17–26. doi: 10.1002/joe.22229

Liu, Y., and He, H. (2023). Scientometrics of scientometrics based on web of science Core collection data between 1992 and 2020. *Information* 14:637. doi: 10.3390/info14120637

Lochner, L., Wieser, H., Oberhöller, G., and Ausserhofer, D. (2020). Interprofessional team-based learning in basic sciences: students' attitude and perception of communication and teamwork. *Int. J. Med. Educ.* 11, 214–221. doi: 10.5116/ijme.5f5b.24e3

Maggio, L. A., Ninkov, A., Frank, J. R., Costello, J. A., and Artino, A. R. (2022). Delineating the field of medical education: bibliometric research approach(es). *Med. Educ.* 56, 387–394. doi: 10.1111/medu.14677

Mogali, S. R., Rotgans, J. I., Rosby, L., Ferenczi, M. A., and Low Beer, N. (2020). Summative and formative style anatomy practical examinations: do they have impact on students' performance and drive for learning? *Anat. Sci. Educ.* 13, 581–590. doi: 10.1002/ase.1931

Neville, A., Norman, G., and White, R. (2019). McMaster at 50: lessons learned from five decades of PBL. *Adv. Health Sci. Educ. Theory Pract.* 24, 853–863. doi: 10.1007/s10459-019-09908-2

Nieder, G. L., Parmelee, D. X., Stolfi, A., and Hudes, P. D. (2005). Team-based learning in a medical gross anatomy and embryology course. *Clin. Anat.* 18, 56–63. doi: 10.1002/ca.20040

Öztürk, O., Kocaman, R., and Kanbach, D. K. (2024). How to design bibliometric research: an overview and a framework proposal. *Rev. Manag. Sci.* 6, 1–29. doi: 10.1007/s11846-024-00738-0

Parmelee, D. X., and Michaelsen, L. K. (2010). Twelve tips for doing effective team-based learning (TBL). *Med. Teach.* 32, 118–122. doi: 10.3109/01421590903548562

Parmelee, D., Michaelsen, L. K., Cook, S., and Hudes, P. D. (2012). Team-based learning: a practical guide: AMEE guide no. 65. *Med. Teach.* 34, e275–e287. doi: 10.3109/0142159X.2012.651179

Parmelee, D., Roman, B., Overman, I., and Alizadeh, M. (2020). The lecture-free curriculum: setting the stage for life-long learning: AMEE guide no. 135. *Med. Teach.* 42, 962–969. doi: 10.1080/0142159X.2020.1789083

Perianes-Rodriguez, A., Waltman, L., and van Eck, N. J. (2016). Constructing bibliometric networks: a comparison between full and fractional counting. *J. Informet.* 10, 1178–1195. doi: 10.1016/j.joi.2016.10.006

Pires, E. M. S. G., Daniel-Filho, D. A., de Nooijer, J., and Dolmans, D. H. J. M. (2020). Collaborative learning: elements encouraging and hindering deep approach to learning and use of elaboration strategies. *Med. Teach.* 42, 1261–1269. doi: 10.1080/0142159X.2020.1801996

Rezende, A. B., de Oliveira, A. G. F., Vale, T. C., Teixeira, L. A. S., Lima, A. R. A., Lucchetti, A. L. G., et al. (2020). Comparison of team-based learning versus traditional lectures in neuroanatomy: medical student knowledge and satisfaction. *Anat. Sci. Educ.* 13, 591–601. doi: 10.1002/ase.1926

Schmidt, H. G., Rotgans, J. I., Rajalingam, P., and Low-Beer, N. (2019). A psychological foundation for team-based learning: knowledge reconsolidation. *Acad. Med.* 94, 1878–1883. doi: 10.1097/ACM.0000000000002810

Sisk, R. J. (2011). Team-based learning: systematic research review. *J. Nurs. Educ.* 50, 665–669. doi: 10.3928/01484834-20111017-01

Smeby, S. S., Lillebo, B., Slørdahl, T. S., and Berntsen, E. M. (2020). Express team-based learning (eTBL): a time-efficient TBL approach in neuroradiology. *Acad. Radiol.* 27, 284–290. doi: 10.1016/j.acra.2019.04.022

Swanson, E., McCulley, L. V., Osman, D. J., Scammacca Lewis, N., and Solis, M. (2019). The effect of team-based learning on content knowledge: a meta-analysis. *Act. Learn. High. Educ.* 20, 39–50. doi: 10.1177/1469787417731201

Thompson, B. M., Schneider, V. F., Haidet, P., Levine, R. E., McMahon, K. K., Perkowski, L. C., et al. (2007). Team-based learning at ten medical schools: two years later. *Med. Educ.* 41, 250–257. doi: 10.1111/j.1365-2929.2006.02684.x

Tricco, A. C., Lillie, E., Zarin, W., O'Brien, K. K., Colquhoun, H., Levac, D., et al. (2018). PRISMA extension for scoping reviews (PRISMA-ScR): checklist and explanation. *Ann. Intern. Med.* 169, 467–473. doi: 10.7326/M18-0850

UNESCO (2021). Pathways to 2050 and beyond. Paris: UNESCO.

Van Eck, N. J., and Waltman, L. (2010). Software survey: VOS viewer, a computer program for bibliometric mapping. *Scientometrics* 84, 523–538. doi: 10.1007/s11192-009-0146-3

Walker, E. R., Lang, D. L., Caruso, B. A., and Salas-Hernández, L. (2020). Role of team dynamics in the learning process: a mixed-methods evaluation of a modified team-based learning approach in a behavioral research methods course. *Adv. Health Sci. Educ.* 25, 383–399. doi: 10.1007/s10459-019-09931-3

Wilson, J. A., Waghel, R. C., and Dinkins, M. M. (2019). Flipped classroom versus a didactic method with active learning in a modified team-based learning self-care pharmacotherapy course. *Curr. Pharm. Teach. Learn.* 11, 1287–1295. doi: 10.1016/j.cptl.2019.09.017

Xiao, C.-L., Ren, H., Chen, H.-Q., Liu, W.-H., Luo, Z.-Y., Li, W.-R., et al. (2023). Multidimensional evaluation of teaching strategies for pharmacology based on a comprehensive analysis involving 21,269 students. *Front. Pharmacol.* 14:1145456. doi: 10.3389/fphar.2023.1145456

Yeung, M. M.-Y., Yuen, J. W.-M., Chen, J. M.-T., and Lam, K. K.-L. (2023). The efficacy of team-based learning in developing the generic capability of problem-solving ability and critical thinking skills in nursing education: a systematic review. *Nurse Educ. Today* 122:105704. doi: 10.1016/j.nedt.2022.105704

Zgheib, N. K., Simaan, J. A., and Sabra, R. (2010). Using team-based learning to teach pharmacology to second year medical students improves student performance. *Med. Teach.* 32, 130–135. doi: 10.3109/01421590903548521

Zhang, F., Wang, H., Bai, Y., and Zhang, H. (2022). A bibliometric analysis of the landscape of problem-based learning research (1981–2021). *Q. Sci. Stu.* 13:828390. doi: 10.3389/fpsyg.2022.828390

Zhang, F., Wang, H., Zhang, H., and Sun, Q. (2024). The landscape of flipped classroom research: a bibliometrics analysis. *Front. Educ.* 9:1165547. doi: 10.3389/feduc.2024.1165547