



Problem-Based Learning in Nurse Education: A Bibliometric Analysis (2000-2025)

Jiaming Fu^{1#}, Jieni Li^{2#}, Zijing Wang^{3#}, Juzhen Li^{4#}, Junyi Fu^{5*}

Abstract

Purpose: Problem-Based Learning (PBL) is a student-centered pedagogical approach that has gained significant traction in healthcare education, particularly in nursing.

Objective: To perform a bibliometric analysis to assess the key areas and trends concerning the interface between nursing education and PBL for the period spanning from 2000 to 2025.

Methods: We gathered articles from the Web of Science Core Collection database and employed two bibliometric tools, CiteSpace and VOSviewer, to evaluate and quantify various impact and collaboration metrics. Our analysis included annual publication data, countries/regions, institutions, authors, and co-cited authors, journals, co-cited journals. Furthermore, we identified emerging research areas linked to PBL and nurse education by investigating the co-occurrence and bursts of keywords and co-cited references.

Results: From 2000 to 2025, 1,317 articles investigating the correlation between nurse education and PBL were published in 258 academic journals. These articles were authored by 5,493 researchers from 1,001 institutions across 71 countries/regions. The United States, China and Australia, emerged as the leading countries in this field, with the United States maintaining a dominant position. University System of Ohio was identified as the most productive institution. Zenobia C Y Chan emerged as the top author, while Benner Patricia and Pamela R Jeffries recorded the highest number of co-citations. The journal *Nurse Education Today* was not only the most prolific in publishing articles at the intersection of nurse education and PBL but was also the journal that received the most co-citations. The main themes of these articles are centered around psychology, education, social health, nursing, and medicine, with keywords frequently relating to education, nurse education, and nurse student.

Conclusion: Stimulation in nurse education remains a significant area of research, contributing to a deeper understanding of the relationship between PBL and nurse education. Emerging areas such as nurse education, virtual learning, and project-based learning may offer valuable guidance and new insights for further research in the field of nurse education.

Keywords: Nurse education; Problem-based learning; Bibliometric analysis; Simulation; CiteSpace; VOSviewer.

Introduction

Problem-Based Learning (PBL) is a student-centered pedagogical approach that has gained significant traction in healthcare education, particularly in nursing [1, 2]. Originating in the 1960s as an innovative method for teaching medical students,

Affiliation:

¹Guangdong Pharmaceutical University, Guangzhou, Guangdong, China. 510006.

²College of Clinical Medicine, Nanchang Medical College, Nanchang, Jiangxi, China, 330052.

³College of Clinical Medicine, Guilin Medical University, Guilin, Guangxi, China, 541001.

⁴Yichun People's Hospital, Yichun, Jiangxi, China, 336000.

⁵Department of Neurology, Institute of Neuroscience, Key Laboratory of Neurogenetics and Channelopathies of Guangdong Province and Ministry of Education of China, The Second Affiliated Hospital of Guangzhou Medical University, Guangzhou, Guangdong, China. 510260.

*Corresponding author:

Junyi Fu at Department of Neurology, The Second Affiliated Hospital of Guangzhou Medical University, Guangzhou, Guangdong, China. 510260.

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PBL emphasizes active learning through the exploration and resolution of complex, real-world problems. Unlike traditional lecture-based instruction, PBL encourages students to engage in collaborative problem-solving, critical thinking, and self-directed learning, all of which are essential competencies for nursing practice [3-5]. In nursing education, PBL serves as an effective framework for bridging theoretical knowledge and clinical application [6]. Nursing students are presented with realistic patient scenarios that require them to identify problems, gather and analyze relevant information, and propose evidence-based solutions [7]. This approach not only deepens their understanding of medical and nursing concepts but also prepares them to address the multifaceted challenges of contemporary healthcare.

PBL is particularly suited to nursing because it fosters skills such as teamwork, communication, and clinical reasoning, all of which are crucial for providing safe, high-quality patient care [8, 9]. Moreover, it cultivates lifelong learning habits, enabling nurses to adapt to rapidly evolving healthcare environments and emerging evidence-based practices.

As nursing education continues to shift toward competency-based frameworks, PBL has become an increasingly valuable tool for developing well-rounded, reflective practitioners. Nevertheless, there have been no bibliometric analyses examining this connection to date. While various methodologies such as traditional reviews, systematic reviews, evidence mapping, and bibliometrics can be employed for quantitative assessments, only bibliometrics can analyze both qualitative and quantitative aspects of authors, institutions, countries, and journals, as well as their contributions and collaborations, thereby evaluating the research landscape and identifying prominent areas of interest. This study intends to utilize two bibliometric tools, CiteSpace and VOSviewer, to quantify the landscape of PBL in nurse education and to pinpoint research trends over the past twenty years, which may offer guidance for future investigations in the intersection of PBL in nurse education.

Methods

Data collection

The Web of Science Core Collection (WoSCC) database is widely used in bibliometrics, which contains Science Citation Index Expanded (SCIE), Social Science Citation Index (SSCI), and Emerging Sources Citation Index (ESCI). Data were obtained from the WoSCC database on February 10, 2026. The search formula was [TS = ("nurse education" AND "problem-based learning OR project-based learning")], and the publication year was limited to (2000-2025). Search results were downloaded as "Full Record and Cited References" and "Plain Text". For further analysis, we

subsequently renamed the files as "download_*.txt", which CiteSpace software could read.

Data Analysis

In this study, we employed various analytical tools, including CiteSpace 6.4.R1 developed by Chaomei Chen, VOSviewer 1.6.20 designed by Nees Jan van Eck and Ludo Waltman, as well as Microsoft Excel 2019, to conduct a thorough bibliometric analysis and visualization of our data. The initial phase of our analysis was data cleaning during which we standardized terms to ensure consistency across our dataset. For example, "nurse education" and "nursing-education" were merged as "nursing education", "problem-based learning" and "problem based learning" were unified as "problem-based learning".

CiteSpace serves as a powerful bibliometric and visual analysis tool, particularly adept at identifying collaborative networks, highlighting key concepts, revealing the internal structure of research areas, and uncovering potential emerging trends and dynamics within a specific scientific field. To leverage CiteSpace effectively, we analyzed the co-occurrence patterns among various countries and institutions, constructed a dual map of journals, tracked citation timelines, observed citation bursts, and examined keyword timelines and bursts. The parameters for our analysis were set to cover the period from 2000 to 2025, with each year examined in one-year increments, and we opted not to prune the data. We established selection criteria focused on the top 100 entries, considered a minimum duration of two years for citation bursts, and utilized light semantic indexing (LSI) and the log-likelihood ratio (LLR) algorithm for extracting cluster labels, while other settings were maintained at their default values. In the visualizations produced by CiteSpace, the size of each node indicates the frequency of co-occurrence, while the links between nodes represent their co-occurrence relationships. Additionally, the color gradients of the nodes and connecting lines denote different years, transitioning from purple to red as we move from the year 2000 to 2025. Notably, nodes that appear as purple circles represent a high betweenness centrality score (≥ 0.10), highlighting their crucial role as bridges within disparate networks.

VOSviewer is a highly effective bibliometric software tool known for its capability to create and visualize knowledge maps. These knowledge maps illustrate various clusters, overlays, and density colors, which help researchers understand the landscape of scholarly communication. In this analysis, VOSviewer was utilized to examine the co-occurrence relationships between authors and their co-cited counterparts, as well as between journals, references, and keywords. We opted for a full counting method, and additional thresholds were detailed in the respective chapter discussing methodology. In the resulting cluster map

generated by VOSviewer, the size of each node corresponds to the frequency of co-occurrences, meaning that larger nodes indicate a higher number of co-occurrences. Moreover, nodes sharing the same color are indicative of belonging to the same cluster of related topics or themes. The connections between these nodes are represented by lines, with the thickness of each line reflecting a calculated strength value. This strength is proportional to the volume of collaborative publications by two researchers or the frequency with which two keywords appear together in the literature. When examining density maps produced by VOSviewer, one can observe that the size and boldness of specific keywords, along with the intensity of the yellow hue, are positively correlated with their co-cited frequency. This provides a clear visual representation of which terms are most prevalent in academic discourse. In contrast, the overlay map utilizes color coding to convey the average year of publication for various works, allowing for a temporal analysis of research trends.

For a more comprehensive analysis of scholarly output, we utilized Excel software to review the annual publication statistics. Additionally, we gathered important metrics such as the impact factor (IF), the Journal Citation Reports (JCR) division of the journals, and the H-index of scholars from the Web of Science database on February 10, 2026, to assess the influence and prominence of the publications and researchers involved in the studied domain.

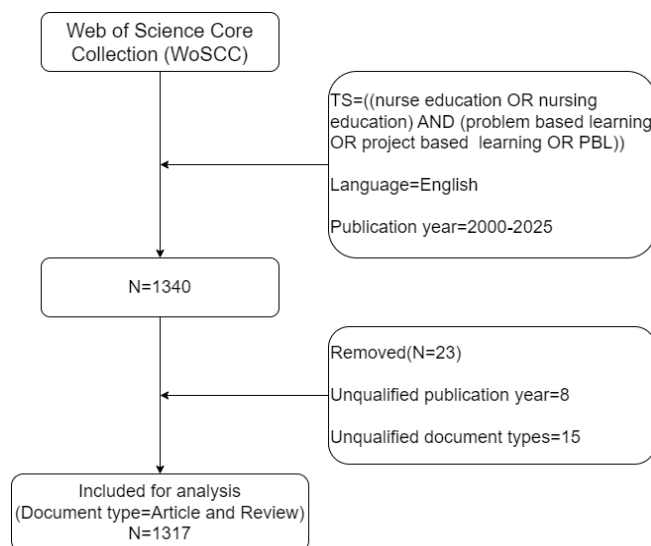


Figure 1: Flow chat of data collection.

Results

Annual Growth Trend

We screened 1317 articles from the WoSCC database for analysis (Figure 1 and Supplementary Table 1). The overall number of articles from 2000 to 2007 was still relatively small, but the number of articles increased gradually during the period from 2008 to 2025 (Figure 2).

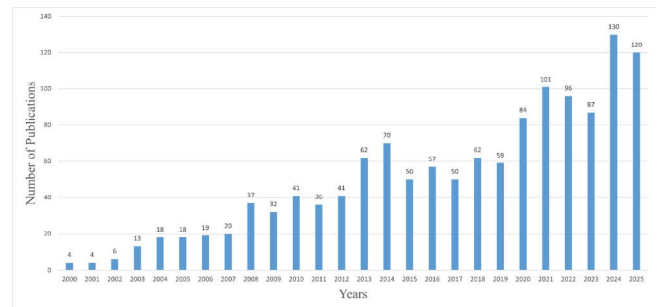


Figure 2: Trends of PBL and nurse education from 2000-2025.

Distribution of countries/regions and institutions

Among the total of 1317 articles, together account for the majority of the publications (Table 1). These articles originate from 71 countries/regions and 1001 institutions (Supplementary Table 2; Supplementary Table 3). The United States published the most articles (n=348), followed by China (n=90) and Australia (n=89). Revised to "Besides," the United States(centrality=0.53), Australia(centrality=0.26), England (centrality=0.29) and Spain (centrality=0.25) have higher centralities, which nodes surrounded by purple rings (Figure 3A), which means the centralities of these countries higher than 0.1 and the United States, Australia and England can be "bridges" nodes in "nurse education and PBL" research. The density of country/region co-occurrence was 0.005, indicating lower cooperation between them. University System of Ohio (n=23) is the most productive institution, followed by Hong Kong Polytechnic University (n=17) and University of North Carolina (n=15). As we can see from Figure 3 and Table 1, University System of Ohio(centrality=0.19), University of California System (centrality=0.10) and University of Wisconsin System (centrality=0.10) have higher centrality.

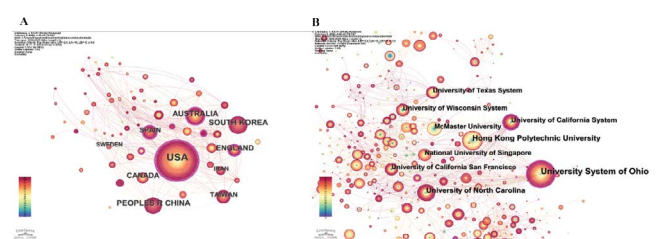


Figure 3: The co-occurrence map of countries and regions (A) and institutions (B) in research about PBL and nurse education. The node size reflects co-occurrence frequencies, while the links illustrate co-occurrence relationships. The color of the nodes and lines represent different years, with colors transitioning from blue to red as the timeline progresses from 2000 to 2025. Nodes depicted in purple circles indicate high betweenness centrality (≥ 0.1).

Author and co-cited author

A total of 5,493 authors were involved in nurse education and PBL research, 325 of them published at least 2 publications (Supplementary Table 4). Table 2 has listed the

Table 1: Top 10 countries/regions and institutions related to nurse education

Rank	Count	Centrality	Years	Countries	Count	Centrality	Years	Institutions
1	348	0.53	2000	USA	23	0.19	2003	University System of Ohio (USA)
2	90	0.02	2001	PEOPLES R CHINA	17	0.01	2001	Hong Kong Polytechnic University (China)
3	89	0.26	2003	AUSTRALIA	15	0.04	2004	University of North Carolina (USA)
4	83	0	2012	SOUTH KOREA	13	0.1	2002	University of California System (USA)
5	71	0.29	2001	ENGLAND	12	0	2002	McMaster University (Canada)
6	70	0.01	2001	CANADA	11	0.03	2002	University of California San Francisco (USA)
7	47	0.07	2004	TAIWAN	11	0.1	2003	University of Wisconsin System (USA)
8	44	0.25	2006	SPAIN	11	0.06	2010	National University of Singapore (Singapore)
9	29	0.01	2008	IRAN	11	0	2004	University of Alberta (Canada)
10	25	0.01	2002	SWEDEN	11	0.03	2005	University of Texas System (USA)

Table 2: Top 10 authors and co-cited authors related to nurse education

Rank	Author	Document	H-index	Co-Cited Author	Citations	H-index
1	Chan, Zenobia C. Y.	7	22	Benner, Patricia	65	13
2	Son, Hae Kyoung	6	8	Jeffries, Pamela R.	63	24
3	Henderson, Amanda M.	5	13	Melnik, Bernadette Mazurek	53	52
4	Boyer, Louise	4	9	Bandura, A	48	26
5	Chang, Ching-Yi	4	21	Polit, Denise	48	24
6	Chou, Fan-Hao	4	23	Schmidt, Henk G.	48	67
7	Hwang, Gwo-Jen	4	81	Braun, Veit	46	13
8	Levett-Jones, Tracy	4	48	Barrows, Howard S.	44	25
9	Palese, Alvisa	4	38	Williams, Beverly A.	43	11
10	Song, Yeongsuk	4	8	Tiwari, Agnes	42	32

top 10 authors who published the most documents. Zenobia C. Y. Chan from Hong Kong Polytechnic University had the highest publications (n=7) of our research, followed by Hae Kyoung Son (n=6) and Henderson Amanda (n=5). As we can see from Figure 4A, it presents the connection network between the authors who published at least two publications. However, it's worth mentioning that 240 of these 242 authors are not connected to each other, so we chose the largest part of the connection network. In this figure, there are three different colors, which means these 73 authors were divided into seven clusters. The authors who have positive cooperations in the same color, authors from different clusters might have cooperations, for instance Palese, Alvisa and Campagna, Sara.

Co-cited authors refer to those individuals whose work is referenced within a particular academic article. In our analysis, out of a total of 20,620 co-cited authors, we identified 58 authors who garnered more than 20 co-citations (Figure 4B; Supplementary Table 5). To illustrate the prominence of these authors, we utilized Figure 4B, which serves as a density map. This visual representation effectively highlights the authors who received the highest frequency of co-citations,

with the color intensity increasing correspondingly with the number of citations. Notably, Table 2 and Figure 4B indicate that Benner P, the World Health Organization, and Jeffries Pr are the authors who have been cited the most frequently.

It is important to acknowledge that the visualizations produced by CiteSpace and VOSviewer come with certain limitations, preventing them from encapsulating all the relevant information available in our study. In light of these constraints, we have provided the complete dataset in Supplementary Table 4 and Supplementary Table 5. This additional information, coupled with the previously presented figures, ensures a more comprehensive understanding of our findings.

Journal and co-cited journal

A comprehensive analysis reveals that a total of 258 journals has published scholarly articles focusing on the area of nursing education and research related to PBL (Supplementary Table 6). Notably, the top 15 among these journals collectively published 749 papers, representing a significant 58.87% of the total publications in this field (Table 3). *Nurse Education Today* had the highest number of

Table 3: Top 15 journals and co-cited journals related to nurse education

Rank	Journal	Count	JCR (2025)	IF (2025)	Cited journal	Cited count	JCR (2025)	IF (2025)
1	NURSE EDUCATION TODAY	194	Q1	4.2	NURSE EDUCATION TODAY	2161	Q1	4.2
2	Nurse Education in Practice	81	Q1	4	JOURNAL OF NURSING EDUCATION	1005	Q2	1.9
3	JOURNAL OF NURSING EDUCATION	60	Q2	1.9	JOURNAL OF ADVANCED NURSING	806	Q1	3.4
4	Nurse Educator	55	Q1	3.4	Nurse Education in Practice	674	Q1	4
5	BMC Medical Education	54	Q1	3.2	MEDICAL EDUCATION	469	Q1	5.2
6	Clinical Simulation in Nursing	48	Q1	2.5	Nursing Education Perspectives	425	Q2	1.4
7	BMC NURSING	47	Q1	3.9	BMC Medical Education	408	Q1	3.2
8	JOURNAL OF PROFESSIONAL NURSING	44	Q1	2.9	MEDICAL TEACHER	376	Q1	4.4
9	CIN-COMPUTERS INFORMATICS NURSING	38	Q2	1.9	Clinical Simulation in Nursing	370	Q1	2.5
10	JOURNAL OF ADVANCED NURSING	33	Q1	3.4	ACADEMIC MEDICINE	369	Q1	5.2
11	International Journal of Environmental Research and Public Health	24	N/A	N/A	JOURNAL OF PROFESSIONAL NURSING	354	Q1	2.9
12	JOURNAL OF CONTINUING EDUCATION IN NURSING	20	Q3	1.4	Nurse Educator	313	Q1	3.4
13	JOURNAL OF CLINICAL NURSING	19	Q1	3.5	JOURNAL OF CLINICAL NURSING	296	Q1	3.5
14	Journal of Interprofessional Care	17	Q2	2.6	INTERNATIONAL JOURNAL OF NURSING STUDIES	254	Q1	7.1
15	Healthcare	15	Q2	2.7	Journal of Interprofessional Care	216	Q2	2.6
16	PUBLIC HEALTH NURSING	15	Q3	1.3				

publications (n=194), followed by *Nurse Education in Practice* (n=81) and *Journal of Nursing Education* (n=60). Among 10,370 co-cited journals, 61 journals have been co-cited at least 50 times (Supplementary Table 7); among which, *Nurse Education Today* (n=2161), *Journal of Nursing Education* (n=1005) and *Journal of Advanced Nursing* (n=806) had the greatest number co-cited citations. Furthermore, the top 15 co-cited journals accounted for 25.12% (Table 3).

The dual-map overlay demonstrating the distribution of topics within academic journals is depicted in Figure 5.

On the left side, the citing journals are displayed, while the cited journals are featured on the right, with colored lines representing the relationships of citations. Figure 5 showed there was one way path from Medicine/Medical/Clinical journals to Health/Nursing/Medicine journals ($z=4.32$, $f=5313$), another way path from Psychology/Education/Health journals to Health/Nursing/Medicine journals ($z=5.08$, $f=6186$) and Psychology/Education/Social journals ($z=2.12$, $f=2787$), the second path way shows that it was a divergency relationship and indicated the topic of our research related to these two journals.

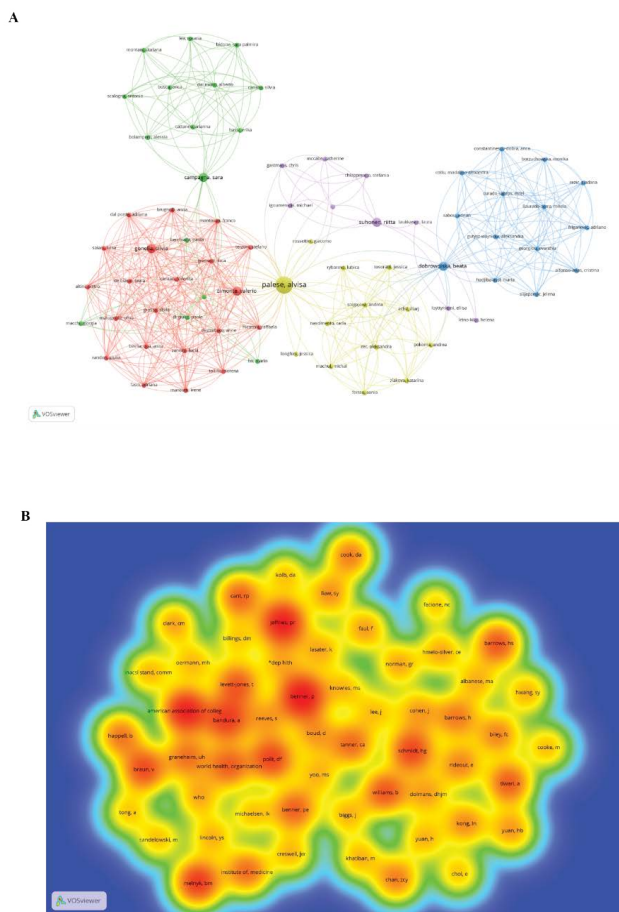


Figure 4: The co-occurrence authors (A) and co-cited authors (B) in research about PBL and nurse education. (A) The size of each node reflects the co-occurrence frequencies of the authors, while the links indicate the co-occurrence relationships between them. The thickness of these links is proportional to the number of publications co-authored by the two researchers, and nodes of the same color represent authors within the same cluster. (B) The size of the words, the size of the circles, and the opacity of the yellow color are positively correlated with the frequency of co-citation.

Co-cited reference and reference burst

Out of the 9,582 references cited in the study, 65 were referenced at least five times, indicating their significance in the field (Supplementary Table 8). According to Table 4, the top ten co-cited references were those that garnered at least eight citations each. Notably, among these ten references, two were unavailable for review. The most co-cited reference were two reviews published in *Medical Care Research and Review* by Robin Peeters from 2023 (n=14) and in *Nurse Education Today* by Jacqueline Wosinski from 2018 (n=14). Furthermore, except one document that not existence, 5 of these co-cited references were articles, and 4 of them were reviews, and an editorial. [10]. Excluding the two unavailable publications, a majority of the co-cited references comprised six articles and two reviews. The reference timeline view

serves to demonstrate the evolution of research hotspots over time. Additionally, the ten most frequently occurring references within each cluster were designated as cluster labels, while the remaining references were cataloged in Supplementary Table 9. As illustrated in Figure 6, cluster #9, focusing on professional task project and interprofessional education, emerged as an early topic of interest. It is worth mentioning that critical thinking and qualitative study are the hot research areas nowadays.

References characterized by citation bursts are those that have experienced a significant increase in citation frequency over a specific timeframe. In total, 357 references were identified as exhibiting citation bursts, and the top twenty most frequently cited among these are displayed in Figure 7. The reference that demonstrated the highest burst strength (5.72) was a paper titled “The effectiveness of problem-based learning on development of nursing students’ critical thinking: A systematic review and meta-analysis,” authored by Ling-Na Kong *et al.* and published in *International Journal of Nursing Studies* in 2014. This reference experienced a citation burst that spanned from 2016 to 2019 [11]. It is noteworthy that seven references are still currently experiencing citation bursts.

Keyword Analysis of Trending Research Topic

A total of 2,940 were extracted, among which 86 keywords appeared at least 10 times, and 23 keywords appeared at least 30 times (Supplementary Table 10). As we can see from Table 6, the top 20 keywords appeared at least 38 times and the highest appearance keywords is education (n=330), followed by nursing education (n=242) and nurse student (n=176).

Figure 8A showed keywords with at least 15 occurrences as an overlay map. As we can see, there are 54 nodes in Figure 8A, and different colors of the nodes present their different publication years, the color much closer to yellow, the newer the keywords. As we can see, simulation, qualitative research, strategies, quality improvement and interprofessional education are emerging fields that were colored yellow. The timeline view (Figure 8B) showed the top 2 (if any) high-frequency keywords in each cluster over time. As we can see from Figure 8B, three of the ten clusters are still ongoing. Among them, #0 (nursing education/virtual learning) is the biggest cluster, followed by 1# (primary care/curriculum development) and 2# (nursing education research/nursing diagnosis). More information was listed in Supplementary Table 11.

Keyword bursts refer to those that have been cited with significant frequency over a specific period. As illustrated in Figure 9, nursing students had the strongest bursts (strength=12.19), followed by nursing education (strength=12.01) and students (strength=7.82). Notably, half of the keywords were still in burstiness until 2025.

Table 4: Top 10 co-cited references related to nurse education

Rank	Title	First Author	Journal	Citations	Document Type	Year
1	So Happy Together: A Review of the Literature on the Determinants of Effectiveness of Purpose-Oriented Networks in Health Care	Peeters, Robin	MEDICAL CARE RESEARCH AND REVIEW	14	Review	2023
2	Facilitating problem-based learning among undergraduate nursing students: A qualitative systematic review	Wosinski, Jacqueline	NURSE EDUCATION TODAY	14	Review	2018
3	The effectiveness of problem-based learning on development of nursing students' critical thinking: A systematic review and meta-analysis	Kong, Ling-Na	INTERNATIONAL JOURNAL OF NURSING STUDIES	13	Review	2014
4	Effects of problem-based learning vs. traditional lecture on Korean nursing students' critical thinking, problem-solving, and self-directed learning	Choi, Eunyoung	NURSE EDUCATION TODAY	11	Article	2014
5	Educating nurses: a call for radical transformation-how far have we come?	Benner, Patricia	JOURNAL OF NURSING EDUCATION	10	Editorial	2012
6	Comparison of problem-based learning and lecture-based learning in midwifery	Sangestani, Gita	NURSE EDUCATION TODAY	10	Article	2013
7	Outcomes of problem-based learning in nurse education: A systematic review and meta-analysis	Sharma, Sapna	NURSE EDUCATION TODAY	10	Review	2023
8	INACSL Standards of Best Practice: SimulationSM Simulation Design	INACSL Stand Comm	CLINICAL SIMULATION IN NURSING	9	Article	2016
9	A comparison of competencies between problem-based learning and non-problem-based graduate nurses	Applin, Harrison	NURSE EDUCATION TODAY	8	Article	2011
10	Lecture-based versus problem-based learning in ethics education among nursing students	Khatiban, Mahnaz	NURSING ETHICS	8	Article	2019

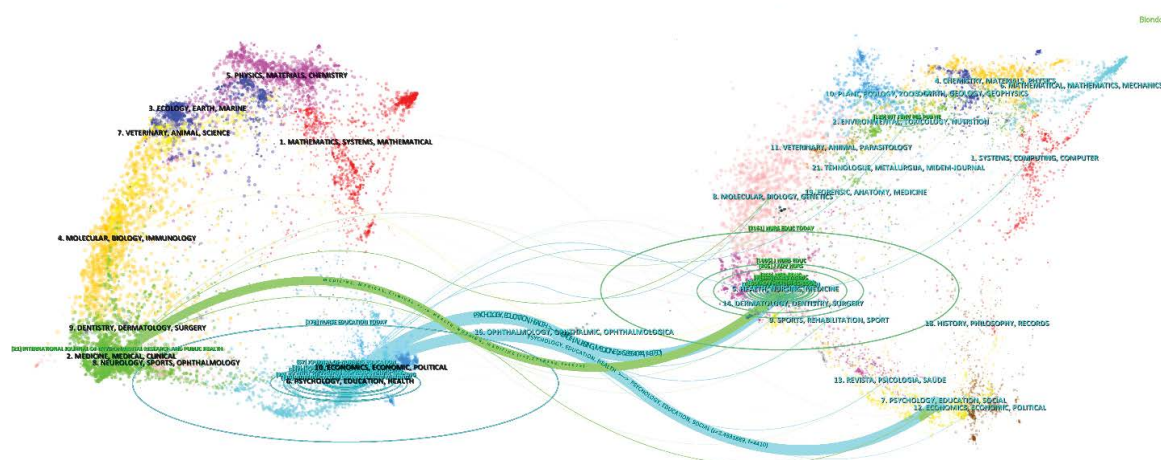


Figure 5: The dual-map overlay of journals on PBL and nurse education. The citing journals are on the left, the cited journals are on the right, and the colored path represents the citation relationship.

Table 5: Top 20 keywords related to nurse education

Rank	Keywords	Occurrences	Rank	Keywords	Occurrences
1	education	330	11	skills	64
2	nursing education	242	12	curriculum	58
3	nursing students	176	13	knowledge	58
4	problem-based learning	158	14	perceptions	48
5	nursing	147	15	performance	47
6	students	146	16	impact	46
7	nurses	131	17	model	44
8	simulation	104	18	experiences	39
9	care	87	19	health	38
10	critical thinking	67	20	program	38

CiteSpace, v. 5.4.R1 (64-bit) Advanced
February 11, 2026, 5:12:10 PM CST
WoS: C:\Users\Kraus\OneDrive\Desktop\nurse education\data
Timespan: 2000-2025 (Slice Length=1)
Selection Criteria: Top 50 per slice, LRF=2.5, L/N=10, LBY=5, e=1.0
Network: N=982, E=25954 (Density=0.0006)
Largest 1 CCs: 5028 (52%)
Nodes Labeled: 1.0%
Pruning: None
Modularity Q=0.9774
Weighted Mean Silhouette S=0.9849
Harmonic Mean(Q, S)=0.9811
Excluded:

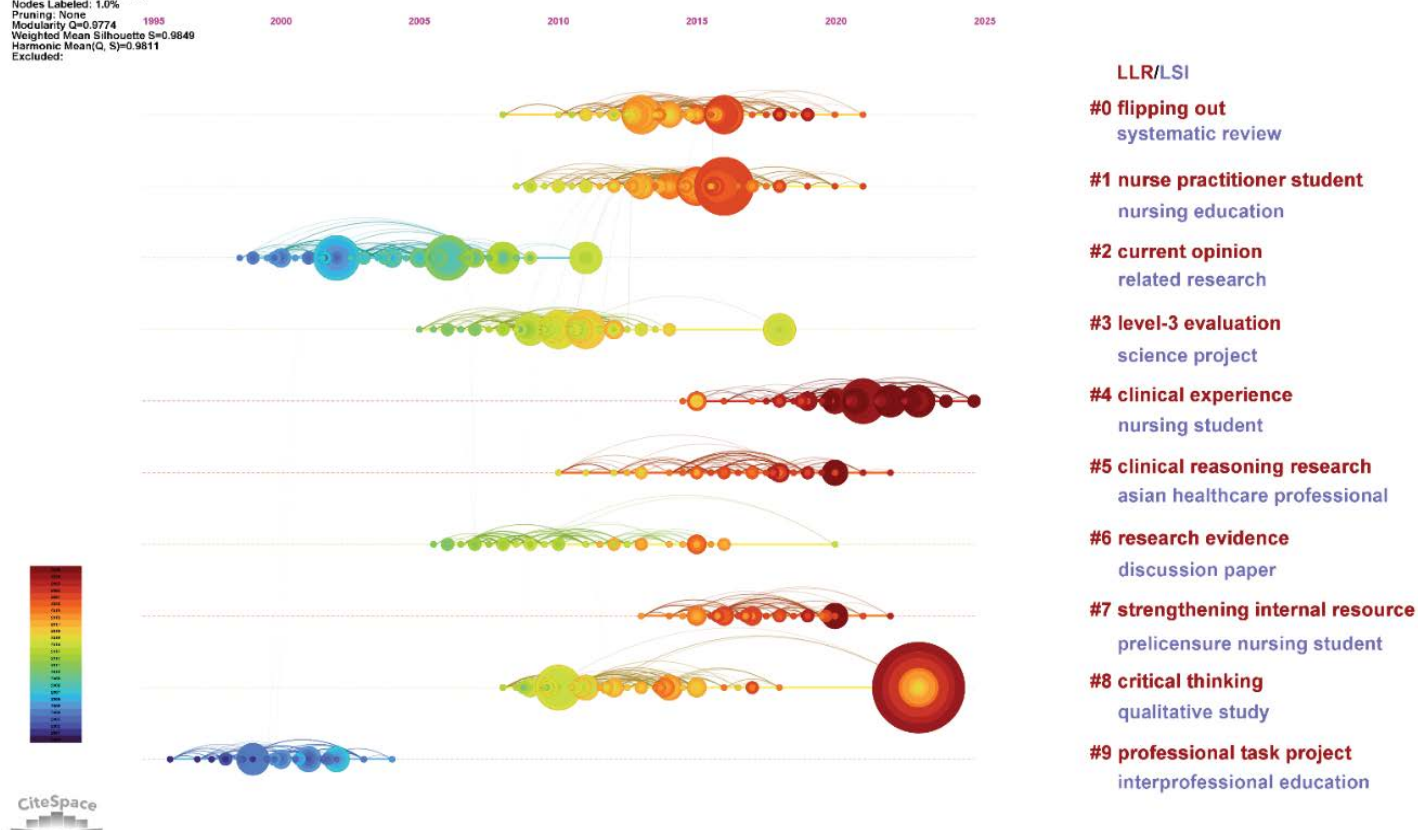


Figure 6: Timeline view of co-cited references related to PBL and nurse education. Each horizontal line represents a distinct cluster. A smaller number indicates a larger cluster, with #0 denoting the largest cluster. The size of each node reflects the frequency of co-citation, while the links illustrate the co-cited relationships. The color of the nodes and lines corresponds to different years, with nodes positioned according to their first year of co-citation. Cluster labels were derived from titles using Light Semantic Indexing (LSI) in red and Log-Likelihood Ratio (LLR) in blue.



Figure 7: Timeline view of co-cited references related to PBL and nurse education. Top 20 references with the strongest citation bursts involved in PBL and nurse education. The blue bars indicate references that have been published, while the red bars represent periods of heightened citation activity.

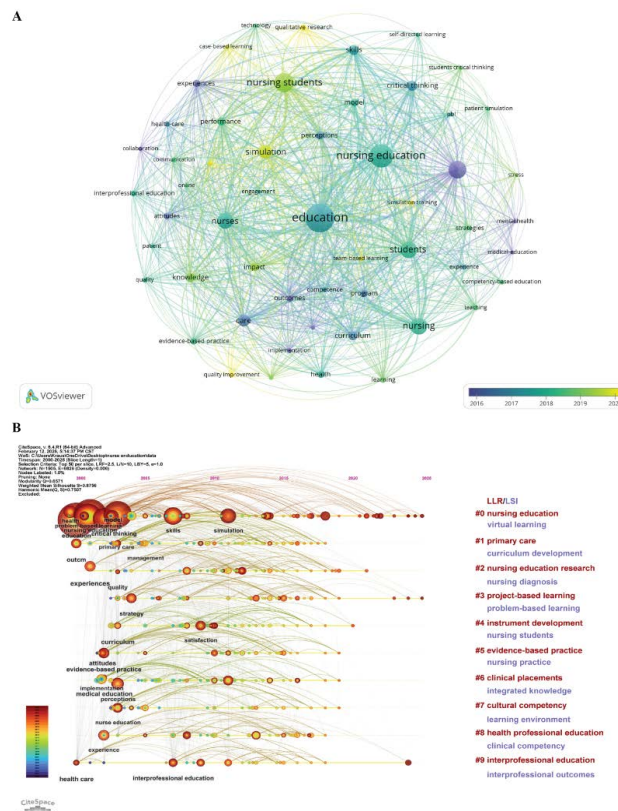


Figure 8: (A) The map of keywords related to PBL and nurse education. The size of each node corresponds to the frequency of co-occurrences, while the links represent the relationships between these co-occurring keywords. The thickness of each link is proportional to the number of times two keywords co-occur, and the color of the links indicates the average year of publication. (B) The timeline view of keywords related to PBL and nurse education. Each horizontal line represents a cluster; the smaller the number, the larger the cluster, with #0 being the largest. The time is indicated at the top, while keywords are positioned at their initial co-occurrence time within the cluster. Cluster labels were derived from title and abstract information using Light Semantic Indexing (LSI) in red and Log-Likelihood Ratio (LLR) in blue.



Figure 9: The timeline view of keywords related to PBL and nurse education. Top 20 keywords with the strongest citation bursts, the red bars mean citation burstiness.

Discussion

General Information

Based on data from the WoSCC database spanning from 2000 to 2025, a total of 1,317 articles exploring the relationship between nurse education and PBL were published across 258 academic journals. These articles were authored by 5,493 authors from 1,001 institutions representing 71 countries and regions. The growing body of research indicates an increasing interest in the association between nurse education and PBL. The investigation of PBL and nurse education began in 1989 when McMillan MA reported an article in *Nurse Education Today*, which exploring problem-based learning in nurse education is provided with a suggested model for formal evaluation of the program [3]. Since then, research in this area has progressed steadily. Over the past decade, the number of publications on PBL and nurse education has significantly increased, with the volume of articles published between 2008 and 2025 nearly five times compared to those published between 2000 and 2007.

In analyzing country and regional involvement, the number of published articles and centrality are key factors to consider. High centrality nodes (≥ 0.10) indicate the 'bridge' effect these countries and regions have on the global cooperation network. Table 1 and Figure 3 illustrate that the United States, Australia and England lead in research on PBL and nurse education. Among the top 10 institutions publishing

research projects, 6 of them are located in the United States, two from Canada, one from Singapore and one from China. Notably, Canada has centrality values below 0.1, while the United States, Australia and England have centrality values of 0.53, 0.26 and 0.29, respectively, suggesting their dominant positions in PBL and nurse education research. Furthermore, the United States, England, Australia, and the Spain all have centralities exceeding 0.1, underscoring their significant roles in global research on PBL and nurse education. Overall, active collaboration among these countries and institutions is evident in terms of network density.

Among the top 10 authors and co-cited authors, Zenobia C Y Chan has published the most articles on PBL and nurse education research, underscoring his significant contributions to these fields. Zenobia Chan currently works at the School of Nursing, The Hong Kong Polytechnic University. Zenobia does research in Qualitative Social Research, Higher Education and Teaching Methods. Her current project is about understanding and developing marking rubrics. Notably, one of her studies published in the journal *Nurse Education Today* in 2013 identified that the types of nursing course promote that confidence and group work may play significant roles in helping students to express themselves and think creatively [12]. Patricia Benner is the leading co-cited author, who is Professor in the Department of Social and Behavioral Sciences at the University of California. Her

research focuses on articulating “on the ground” knowledge and clinical wisdom of the practicing nurse and nurse educators. In 2012, Patricia Benner published an editorial in *The Journal of Nursing Education* that mentioned a call for radical transformation which emphasis on clinical reasoning and nursing domain-specific pedagogies [13]. She suggested more focus to help diminish the current practice-education gap.

The journal *Nursing Education Today* is recognized for publishing a substantial amount of research in the fields of PBL and nurse education, and it is distinguished by having the highest number of co-citations. This assertion is supported by the fact that four of the top ten highly cited papers were published in *Nurse Education Today*. These journals primarily concentrate on nurse studies, medical education, and related disciplines. Furthermore, *Nurse Education Today* ranks first in the number of articles published, highlighting its significance in the dissemination of research concerning PBL and nurse education. Dual-map analysis indicates that research in these areas is predominantly centered around health, nursing, education, and medicine.

The set of references that are frequently cited together within a specific research community may reflect the collective knowledge base. Among the top ten cited references, seven primarily address PBL in nurse education, emphasizing the comparison between PBL and other teaching methods, and PBL in critical thinking of nursing students. Additionally, one article focused on nursing education reform and interorganizational collaboration. It promoted macro-level changes in nursing education and determinants of effectiveness in purpose-oriented networks within healthcare. These findings suggest that PBL significantly influences nurse education through its positive effects on nurse students.

Regarding burst analysis, the absence of references currently in burst indicates a need for further study on the intersection of PBL and nurse education. The strongest burst suggests the evidence on undergraduate nursing student with PBL, enhancing critical thinking and collaboration skills.

The Hotspots and Trending

Nowadays, it is very important for researchers to quickly understand current research hot spots. Therefore, bibliometrics provides a quantitative method that can reflect research hot spots in the academic field through keyword co-occurrence. Overlap and timeline views can reflect the development of new research, and reference clusters and citation bursts can represent emerging topics. This study attempts to objectively evaluate through keyword co-occurrence (Table 5), keyword overlap and timeline (Figure 8), keyword burst (Figure 9), reference timeline (Figure 6), reference burst (Figure 7), etc. Hot spots and trending PBL in nurse education research.

PBL in nursing education

PBL emphasizes student-centered learning, guiding students to actively engage through real-world problems. This approach is particularly important in nursing education, where integrating theoretical knowledge with clinical practice is essential [14, 15]. The findings of this study indicate that PBL significantly enhances students' self-directed learning and critical thinking skills [16-19]. Through group discussions and collaborative tasks, students deepen their understanding of knowledge and develop teamwork skills, which are crucial in modern healthcare environments [11, 20].

PBL provides a learning platform that simulates real clinical scenarios. Nursing students analyze problems, develop care plans, and make decisions in simulated cases, which improves their clinical competence [21]. The study found that students exposed to PBL demonstrated greater confidence and efficiency in actual nursing practice [22]. Moreover, PBL stimulates students' interest in learning. Compared to traditional lecture-based teaching, PBL uses problem-driven methods to encourage students to actively explore solutions [23-25]. This approach enhances their engagement and satisfaction with the course, leading to better learning outcomes [26-28].

Despite its advantages, PBL faces several challenges in its implementation. Some educators reported difficulty managing time and addressing the varied learning progress of students during PBL sessions [29]. PBL may increase students' learning pressure [30]. Due to the vast and complex knowledge base of nursing, students are required to solve problems and complete tasks within limited timeframes, which can lead to feelings of anxiety and stress for some [31, 32].

PBL has significant advantages in nursing education, particularly in fostering students' comprehensive abilities. However, challenges such as insufficient teacher training, increased student stress, and limited resource allocation must be addressed. Future research should explore strategies to optimize the implementation of PBL in diverse teaching environments to better meet the needs of nursing education.

Simulation-based training in nursing education

Simulation-based training (SBT) has become a cornerstone of modern nursing education due to its ability to create realistic and controlled learning environments [33]. One significant advantage of SBT is the opportunity for students to practice clinical skills in a safe, non-threatening environment [34]. This allows learners to make mistakes and refine their techniques without the risk of harming actual patients [35].

SBT also enhances students' clinical decision-making and critical thinking skills. By exposing students to realistic

scenarios, such as emergency situations or complex patient cases, they learn to prioritize tasks, communicate effectively with healthcare teams, and make timely decisions under pressure [36, 37]. These experiences are invaluable in preparing students for real-world clinical challenges.

Repeated practice in simulated settings enables students to become more familiar with clinical procedures and protocols, leading to a smoother transition into actual clinical practice [38]. Some studies found that students trained through simulation reported greater self-assurance in handling clinical tasks compared to those who received only traditional lectures [39]. Educators can design scenarios that address particular skills or knowledge gaps, ensuring that training is tailored to the needs of the learners. This flexibility makes SBT a versatile tool in nursing education [40].

Outlook and Limitations

This study represents the first bibliometric analysis systematically examining publications in PBL and nurse education over the past two decades. Unlike traditional reviews, bibliometric analysis offers a novel and objective perspective on the evolving trends within this research field. We employed various bibliometric software tools for analysis, yielding more results across multiple dimensions [41]. This study aims to enhance public understanding of the significance of PBL in nurse education, provide scholars with a comprehensive overview of research in this area, and offer objective guidance for the future development of PBL and medical education research. However, this study has certain limitations. Firstly, we exclusively searched the WoSCC database for published English articles, thereby excluding non-WoSCC and non-English publications. Nonetheless, English articles in WoSCC are the most frequently utilized data source in bibliometrics and can represent a substantial portion of the relevant information. Secondly, the bibliometric methodology relies on natural language processing, which may introduce biases, as noted in other bibliometric studies [42]. Despite these limitations, our findings provide a more comprehensive and objective overview of the field. Furthermore, the sample reflects the current volume of research on PBL and nurse education, indicating that this area is an emerging direction for future inquiry.

Conclusion

In summary, research on PBL and nurse education has progressed steadily over the past two decades, characterized by active collaboration. The United States holds a prominent position in this research domain. Zenobia C Y Chan has published the highest number of articles, while Benner Patricia is the most frequently co-cited author. Simulation in nurse education remains a prevalent research topic, contributing to a better understanding of the interplay

between PBL and nurse education. Emerging areas such as nurse education, virtual learning, and project-based learning may offer valuable guidance and new insights for further research in the field of nurse education.

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Author Contributions

Jiaming Fu and Zijong Wang designed and conceived this study. Jiaming Fu and Jieni Li collected the data. Juzhen Li and Zijong Wang analyzed the data. Junyi Fu wrote the manuscript. Juzhen Li and Junyi Fu revised the paper. Each author contributed important content during manuscript drafting or revision and accepts accountability for the overall work, and all the authors agreed on the final manuscript.

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Data Statement

The datasets generated and/or analyzed during the current study are not publicly available due to part of the data in the study related to other studies but are available from the corresponding author on reasonable request.

Disclosure

The authors declare that there is no conflict of interest that could be perceived as prejudicing the impartiality of the research reported.

Ethical Approval

This article does not contain any studies with human participants or animals performed by any of the authors.

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