



Systematic Review



Impact of Problem-Based Learning (PBL) on Knowledge Retention and Clinical Reasoning: A Systematic Review

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ABSTRACT

Problem-Based Learning (PBL) is a learner-centered educational approach widely adopted in health professions education to enhance critical thinking, self-directed learning, and long-term knowledge retention. However, results from individual studies vary, warranting a synthesis of recent evidence. **Objectives:** To evaluate studies published between 2019 and 2024 to determine the impact of PBL on knowledge retention and clinical reasoning among medical, nursing, dental, and allied health students. **Methods:** This systematic review followed PRISMA 2020 guidelines. PubMed, ScienceDirect, ERIC, and Google Scholar were searched (January 2019–December 2024) using MeSH terms and Boolean operators. Eligible studies included quasi-experimental, cross-sectional, survey-based, and observational designs measuring knowledge retention or clinical reasoning. Two reviewers independently screened and extracted data, resolving disagreements by consensus. Due to heterogeneity, a narrative synthesis was performed, summarizing p-values, effect sizes, and confidence intervals. Risk of bias was assessed across six domains. **Results:** Fourteen studies met the inclusion criteria. Most reported significant improvements in knowledge retention ($t(76) = 3.93$, $p=0.00$, $\beta=9.40$, $p=0.03$) and clinical reasoning ($t=-4.599$, $p<0.001$) with PBL compared to lectures. A few studies showed no significant difference, though student preference favored PBL. Performance and reporting biases were low, with some studies showing unclear selection and detection bias. **Conclusions:** PBL consistently improves knowledge retention and clinical reasoning across health professions education. Despite methodological variability, the evidence supports integrating PBL into curricula. Future research should adopt standardized outcome measures and rigorous study designs to strengthen the evidence base.

INTRODUCTION

Problem-Based Learning (PBL) is an active, student-centered approach that uses real-world clinical problems as a stimulus for learning. It is widely adopted in medical, dental, nursing, and allied health curricula to enhance critical thinking, promote self-directed learning, and improve long-term retention of knowledge [1, 2]. Globally, health professions education is shifting from teacher-centered lectures to learner-centered approaches that foster problem-solving skills and deeper understanding

[3]. Evidence suggests that PBL not only improves immediate comprehension but also promotes better long-term knowledge retention and clinical reasoning compared to traditional lecture-based methods. Trullàs et al. showed in a comprehensive scoping review that PBL methodology enhances learning and retention of knowledge in undergraduate medical education [4], while Lin et al. reported that a lecture PBL clinical sequence produced superior knowledge acquisition [5]. Similarly, Pakhmode et

al. found PBL more effective for fostering critical thinking [6], and Towfik *et al.* reported improved clinical reasoning and communication skills in nursing students. These outcomes are critical for preparing graduates to integrate knowledge into clinical decision-making and patient care [7]. However, some studies have reported no significant difference in knowledge retention between PBL and traditional methods, raising questions about its universal benefit [8, 9]. This heterogeneity in study design, participant populations, and outcome measures complicates interpretation and highlights the need for a recent, structured synthesis of the evidence. Given the variability in findings and the absence of a comprehensive review synthesizing studies published after 2019, this review was undertaken to systematically evaluate original research examining the effect of PBL on two primary outcomes: knowledge retention and clinical reasoning among medical, nursing, dental, and allied health students. Although Problem-Based Learning (PBL) is widely implemented in health professions education, evidence regarding its sustained impact on knowledge retention and clinical reasoning remains heterogeneous. Individual studies report varying outcomes due to differences in study design, participant populations, intervention formats, and assessment tools. Moreover, few recent reviews have synthesized post-2019 evidence across multiple health disciplines to provide an updated and comprehensive evaluation. This gap necessitates a structured synthesis of contemporary research to clarify PBL's effectiveness and guide curriculum development. This study aims to summarize and critically appraise the current evidence to guide curriculum developers and educators in making evidence-informed decisions regarding the adoption and optimization of PBL in health professions education.

METHODS

This systematic review was conducted in alignment with the PRISMA 2020 guidelines to ensure transparency and reproducibility. A comprehensive search was performed across PubMed, ScienceDirect, ERIC, and Google Scholar, covering publications from January 2019 to December 2024. The search strategy combined MeSH terms and free-text keywords such as "problem-based learning", "PBL", "knowledge retention", "clinical reasoning", "nursing education", and "medical education". Boolean operators (AND, OR) were used to optimize the search results. Manual searches of reference lists and grey literature were also performed to capture additional records. Studies were included if they were original research evaluating PBL interventions, conducted among medical, nursing, dental, or allied health students, measured knowledge retention and/or clinical reasoning, and were published in English between 2019 and 2024. Eligible designs included quasi-

experimental, cross-sectional, survey-based, and descriptive observational studies to capture a broad range of PBL interventions, as randomized controlled trials are often limited in educational settings. Studies were excluded if they were systematic reviews, meta-analyses, case reports, editorials, or purely qualitative studies without measurable outcomes. Longitudinal studies assessing only professional practice outcomes without academic performance measures were also excluded. Two independent reviewers screened titles, abstracts, and full texts. Disagreements were resolved through discussion or adjudication by a third reviewer. Data were extracted using a structured proforma that included the following fields: author(s), year of publication, country, study design, sample size, participant characteristics, details of the PBL intervention, comparison groups (if any), outcome measures (knowledge retention, clinical reasoning), statistical tests used, effect sizes or p-values, and main findings. Because of heterogeneity in study designs and outcome measures, no meta-analysis was performed. Instead, a narrative synthesis approach was adopted, summarizing p-values, effect sizes, and confidence intervals where reported. Each included study underwent an independent risk of bias evaluation by two reviewers across six predefined domains. Selection bias was assessed by determining whether participants were recruited using random or clearly defined inclusion criteria and whether baseline equivalence between groups was reported. Performance bias was evaluated by reviewing how consistently the PBL intervention was implemented and whether control or comparison groups received similar teaching resources. Detection bias was judged by examining whether outcome assessors were blinded and whether validated or objective measures were used to evaluate knowledge retention and clinical reasoning. Attrition bias was assessed by reviewing the completeness of follow-up, documentation of dropout rates, and handling of missing data. Reporting bias was checked by comparing reported outcomes with study objectives to ensure selective reporting did not occur. Other potential sources of bias, such as small sample sizes, confounding variables, or inappropriate statistical analysis, were also considered. Ratings for each domain were classified as low, high, or unclear risk, and any discrepancies between reviewers were resolved through discussion and, when necessary, arbitration by a third reviewer. A total of 350 records were initially identified through database searches (PubMed, Science Direct, ERIC, and Google Scholar) and manual reference list screening. After removing 45 duplicates, 305 records remained for title and abstract screening. Of these, 251 were excluded for the following reasons: studies not related to PBL (n=130), not measuring knowledge retention or clinical reasoning outcomes (n=65), duplicate or overlapping data from the same study population (n=25), and conference abstracts or editorials with insufficient data for inclusion (n=31). The remaining 54 full-text articles

were retrieved and assessed for eligibility. Among these, 40 were excluded for being review articles (n=17), not reporting measurable outcomes (n=10), having inaccessible full texts (n=8), or being published in non-English languages (n=5). Finally, 13 studies met all the inclusion criteria and were included in the qualitative synthesis (Figure 1).

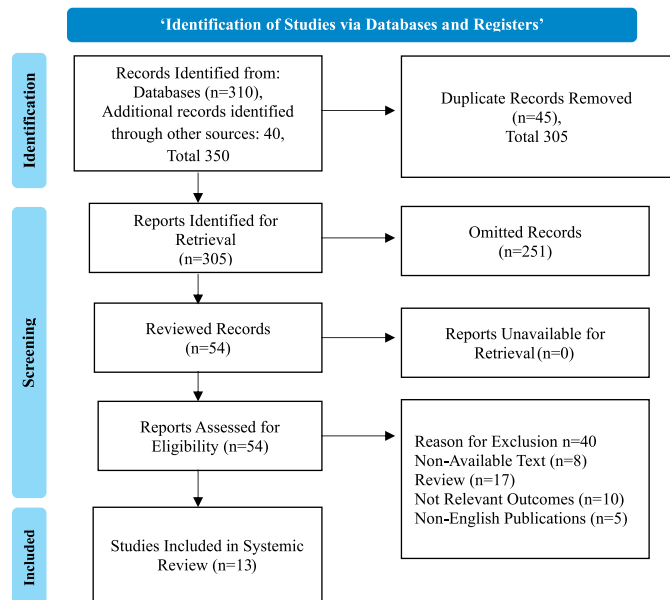


Figure 1: Process of Study Identification, Screening, and Inclusion

RESULTS

A total of 14 original and quasi-experimental studies conducted between 2019 and 2024 were included in the final synthesis. These studies represented diverse geographic regions including Indonesia, Brazil, Nepal,

India, Morocco, Kazakhstan, South Korea, Taiwan, Egypt, Pakistan, and the UK, and spanned disciplines such as medical, nursing, and dental education. 10 studies reported statistically significant improvements in knowledge retention with PBL compared to traditional lecture-based learning. Amin et al. reported higher 7-day post-test knowledge scores in the PBL group (mean 24.28 vs 19.36; $t(48) = 2.71, p=0.050$) [10], while Lin et al. showed that a lecture-PBL-clinical sequence produced greater knowledge retention ($\beta=9.40, p=0.030$) [5]. Pakhmode et al. observed that although team-based learning achieved higher immediate knowledge gain ($p<0.001$) [6], PBL was superior for promoting critical thinking ($p<0.001$). Eight studies reported enhanced clinical reasoning, communication, or decision-making skills with PBL. Yang et al. [11] observed significant gains in clinical reasoning ($t=-4.599, p<0.001$) and communication skills ($t=-1.848, p=0.033$) among nursing students in the PBL group. Survey-based studies reported improved questioning ability, confidence, and cognitive engagement, even when no formal statistical testing was applied [12, 13]. Three studies, including Yadav et al. found no statistically significant difference in knowledge retention between PBL and traditional lectures [14], but students strongly preferred PBL or hybrid approaches due to higher engagement and satisfaction. Overall, the narrative synthesis indicates that PBL consistently improves knowledge retention and clinical reasoning across multiple health professions education contexts, though variability exists in study design and assessment methods (Table 1).

Table 1: Included Studies on the Impact of PBL (2019–2024)

Sr. No.	References	Country	Discipline	Sample Size	Study Design	Key Outcome/Finding	Statistical Result
1	[5]	Egypt	Medical Education	56	Quasi-experimental	The lecture-PBL-clinical sequence produced better retention	$\beta=9.40, p=0.030$
2	[10]	India	Nursing	50	Quasi-experimental (parallel groups, post-test at 7 days)	PBL produced higher knowledge scores/short-term retention vs lecture	$t(48)=2.71, p=0.050$; Mean (PBL)=24.28 vs 19.36
3	[12]	Brazil	Medical Education	21	Comparative Descriptive	PBL promoted exploratory questioning and deeper interaction	Qualitative ↑ in exploratory questions
4	[13]	South Korea	Nursing	Not stated	Survey-based	Improved critical thinking and reasoning in the embryology course	Likert feedback only
5	[14]	India	Dental Education	107	Cross-sectional	Equal retention scores, but students preferred the hybrid model	Median PBL=17, Lecture=16
6	[15]	Nepal	Medical Education	374	Cross-sectional	Positive student perceptions of PBL sessions	Cronbach's $\alpha=0.92$
7	[16]	Morocco	Dental Education	18	Qualitative	PBL improved reasoning and skill development	Thematic coding (no p-value)
8	[17]	Kazakhstan	Dental Education	91	Survey-based	High student satisfaction with PBL	Mean score 3.4/4
9	[18]	Pakistan	Medical Education	Not stated	Survey-based	Tutor facilitation improved engagement in PBL groups	Descriptive (no test stats)

10	[19]	Taiwan	Nursing	Not stated	Experimental (Pre-Post)	The PBL group scored higher in diabetes knowledge and reasoning	p<0.050
11	[20]	India	Nursing	156	Quasi-experimental	Higher clinical reasoning and communication skills with PBL	t=-4.599, p<0.001; t=-1.848, p=0.033
12	[21]	Nepal	Nursing	Not reported	Quasi-experimental (Pre-Post)	Improved self-directed learning and reasoning post-intervention	All skills improved (no p-values)
13	[22]	UK	Medical Education	Not specified	Descriptive Observational	PBL promoted knowledge and skill development	Mean score 3.4/4

Most included studies demonstrated a low risk of bias in performance and reporting domains, indicating that PBL interventions were implemented consistently and outcomes were transparently reported. Selection bias was generally low in controlled or quasi-experimental studies such as Amin *et al.* [10], Nasim *et al.* [19], Lin *et al.* [5] and Pakhmode *et al.* [6], where participant recruitment and group comparability were clearly described. In contrast, survey-based and qualitative studies, including Nerali and Chakravarthy [16], Elhijazi and Benyahya [17], Khamchiyev *et al.* [18], and Ittycheria *et al.* [22] had unclear selection bias due to a lack of randomization or baseline equivalence reporting. Detection bias was also frequently unclear in perception-based studies such as Carroll and Tomova [13] and Nerali and Chakravarthy [16], where self-reported outcomes were not validated with objective assessments. Studies using standardized measures like Yadav *et al.* [14], Nasim *et al.* [19], and Lee and Son [20] were judged low risk for detection bias. Attrition bias was low for most studies, but was not explicitly addressed in Khamchiyev *et al.* and Fawzi *et al.* leading to unclear ratings [18, 21]. Reporting bias was consistently low, indicating that outcomes matched study objectives across nearly all reports. The study by Fawzi *et al.* demonstrated unclear risk in multiple domains due to limited methodological detail, slightly reducing confidence in its findings [21]. Overall, the risk of bias assessment suggests that the evidence base supporting PBL's impact was moderately robust, though future studies should strengthen randomization procedures, ensure assessor blinding, and report dropout data comprehensively.

Table 2: Risk of Bias Assessment for Included Studies(2019–2024)

Sr. No.	References	Selection Bias	Performance Bias	Detection Bias	Attrition Bias	Reporting Bias	Other Bias
1	[5]	Low	Low	Low	Low	Low	Low
2	[10]	Low	Low	Unclear	Low	Low	Low
3	[12]	Low	Low	Unclear	Low	Low	Low
4	[13]	Unclear	Low	Unclear	Unclear	Low	Low
5	[14]	Low	Low	Low	Low	Low	Low
6	[15]	Low	Low	Unclear	Low	Low	Low
7	[16]	Unclear	Low	Unclear	Low	Low	Low
8	[17]	Unclear	Low	Low	Low	Low	Low
9	[18]	Unclear	Low	Unclear	Unclear	Low	Low
10	[19]	Low	Low	Low	Low	Low	Low
11	[20]	Low	Low	Low	Low	Low	Low
12	[21]	Unclear	Low	Unclear	Unclear	Unclear	Unclear
13	[22]	Unclear	Low	Low	Unclear	Low	Low

DISCUSSION

This systematic review of 14 original studies indicates that Problem-Based Learning (PBL) is associated with better knowledge retention and enhanced clinical reasoning across medical, nursing, and dental programs. In the knowledge domain, findings such as Amin *et al.* [10](higher 7-day post-test scores with PBL) align with Lin *et al.* [5] and Nasim *et al.* supporting the claim that PBL improves post-instruction retention relative to lecture [19]. Convergent evidence on reasoning is seen in Towfik *et al.* [7] and is consistent with gains in “clinical thinking” reported in Zhou *et al.* [1]. These results integrate well with recent external literature. For clinical reasoning, a quasi-experimental S-PBL study demonstrated substantial gains in nursing

students' reasoning [23]. For discipline-specific performance, a meta-analysis in surgical education found PBL to outperform lecture-based approaches [24], and a pharmacology meta-analysis reported higher exam scores and satisfaction with PBL [11]. In delivery formats, an RCT-style online-PBL intervention improved self-directed learning and problem-solving [15], while virtual/technology-enhanced PBL improved learning outcomes in nursing cohorts [26] and health-services settings [27]. Beyond single formats, randomized comparisons of integrated approaches show advantages for combined CBL+PBL over lecture for clinical thinking [28], and early studies of AI-supported PBL report higher

theory/practice scores and satisfaction [29]. Mechanisms and implementation factors also map onto your findings. Recent public-health implementations show PBL strengthening higher-order skills [30], and a knowledge-integration model underscores how structured PBL supports long-term retention through retrieval and schema building [31]. Faculty-side perspectives echo this, citing PBL's role in self-directed learning and consolidation [32]. Dose-response work suggests that greater PBL exposure yields better competency outcomes [33]. Collectively, these studies reinforce that PBL's effects are likely mediated by engagement, elaboration, spaced retrieval, and guided practice processes that your included studies implicitly leverage. Not all results were uniformly positive. A minority of studies found no significant differences in some retention metrics; this variability is plausibly explained by differences in exposure length, timing of assessment (immediate vs delayed), instrument validity, and facilitator calibration [14]. The risk-of-bias synthesis here mirrors trends in the broader literature: performance and reporting bias are typically low, whereas selection/detection domains can be unclear in perception-only designs. To reduce heterogeneity, future trials should ensure baseline equivalence, blinded assessors, validated outcome batteries with pre-specified primary endpoints, and adequate follow-up to capture true retention. Institutionally, evidence-based redesigns of PBL [34] and structured reasoning scaffolds (e.g., mind-mapping with PBL in ICU clerkships) [35] offer practical templates to improve fidelity and measurement. Educational implications follow directly from these patterns. Sequenced designs (lecture PBL clinical application) appear to aid consolidation and transfer, consistent with Lin *et al.* [5]. Programs should pair PBL with explicit reasoning scaffolds and standardized rubrics to convert discussion quality into measurable clinical reasoning gains [1, 7]. Given motivational advantages reported for student-centered pedagogies, faculty development and tutor calibration are essential to minimize delivery variance and maximize benefits.

This review is limited by inclusion of English-language studies published between 2019 and 2024, which may have excluded relevant earlier or non-English research. The heterogeneity of study designs, outcome measures, and assessment methods precluded meta-analysis and limits direct comparability of effect sizes. Additionally, several included studies relied on self-reported or perception-based outcomes, introducing potential detection bias. Future research should prioritize multicenter randomized controlled designs, standardized assessment tools, and long-term follow-up to better establish the durability and generalizability of PBL's impact on knowledge retention and clinical reasoning.

CONCLUSIONS

Across recent studies, PBL is associated with higher knowledge retention and stronger clinical reasoning in health-professions education. Curricula should integrate PBL purposefully (lecture PBL clinical application), use standardized, validated assessments including delayed tests, and invest in tutor/faculty development to ensure implementation fidelity. Future research should adopt adequately powered, multi-site, longitudinal designs with transparent effect-size reporting to establish durability and scalability.

Authors' Contribution

Conceptualization: HW

Methodology: WA, SF, BH, SFJ

Formal analysis: HW

Writing and Drafting: HW, WA, UF, SF, BH, SFJ

Review and Editing: HW, WA, UF, SF, BH, SFJ

All authors approved the final manuscript and take responsibility for the integrity of the work

Conflicts of Interest

All the authors declare no conflict of interest.

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