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Characteristics of problem-based learning in the development of critical thinking skills: a systematic review.

Características del aprendizaje basado en problemas en el desarrollo de las habilidades del pensamiento crítico: revisión sistemática.

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Summary.
Introduction: The development of critical thinking is a priority challenge in medical education, where informed decision-making is essential for clinical practice. Problem-based learning (PBL) has established itself as a pedagogical strategy that integrates inquiry, reasoning, and reflection. Classic meta-analyses have demonstrated its benefits in the transfer and integration of knowledge, but there is still a need to specifically evaluate its impact on critical thinking in health sciences. **Objective:** To analyze the characteristics of PBL and its influence on the development of critical thinking skills in medical and health sciences students. **Methods:** A systematic review was conducted in accordance with the PRISMA 2020 declaration. A search was conducted in PubMed, Scopus, and CINAHL between January 2000 and December 2024, in English and Spanish. Seventy-eight records were identified; after eliminating duplicates and applying inclusion and exclusion criteria, 18 studies were included in the qualitative synthesis. **Results:** The interventions (8–16 weeks) included classical PBL and derived models such as 3C3R and IDEAS. Significant improvements were observed in cognitive skills (interpretation, analysis, evaluation, inference, explanation, and self-regulation) and attitudinal dispositions (critical reflection, inquiry, curiosity, and autonomous learning). In medical education, the effects were especially noticeable in clinical reasoning and decision-making. **Conclusions:** PBL is an effective methodology for enhancing critical thinking in medical students, consolidating its position as a structural component in medical training. Its systematic incorporation into curricula and the conduct of multicenter and longitudinal research to strengthen the evidence in different clinical and educational contexts are recommended.

Keywords: Problem-Based Learning; Critical Thinking; Medical Education; Teaching Strategies.

Resumen.
Introducción: El desarrollo del pensamiento crítico constituye un desafío prioritario en la educación médica, donde la toma de decisiones fundamentadas es esencial para la práctica clínica. El Aprendizaje Basado en Problemas (ABP) se ha consolidado como una estrategia pedagógica que integra indagación, razonamiento y reflexión. Metaanálisis clásicos han demostrado sus beneficios en la transferencia e integración del conocimiento, pero persiste la necesidad de evaluar de manera específica su impacto sobre el pensamiento crítico en ciencias de la salud. **Objetivo:** Analizar las características del ABP y su influencia en el desarrollo de habilidades de pensamiento crítico en estudiantes de medicina y ciencias de la salud. **Métodos:** Revisión sistemática realizada conforme a la declaración PRISMA 2020. Se efectuó una búsqueda en PubMed, Scopus y CINAHL entre enero de 2000 y diciembre de 2024, en inglés y español. Se identificaron 78 registros; tras eliminar duplicados y aplicar criterios de inclusión y exclusión, se incluyeron 18 estudios en la síntesis cualitativa. **Resultados:** Las intervenciones (8–16 semanas) incluyeron ABP clásico y modelos derivados como 3C3R e IDEAS. Se observaron mejoras significativas en habilidades cognitivas (interpretación, análisis, evaluación, inferencia, explicación y autorregulación) y en disposiciones actitudinales (reflexión crítica, indagación, curiosidad y aprendizaje autónomo). En educación médica, los efectos fueron especialmente notorios en razonamiento clínico y toma de decisiones. **Conclusiones:** El ABP es una metodología eficaz para potenciar el pensamiento crítico en estudiantes de medicina, consolidándose como un componente estructural en la formación médica. Se recomienda su incorporación sistemática en los planes de estudio y la realización de investigaciones multicéntricas y longitudinales que robustezcan la evidencia en diferentes contextos clínicos y educativos.

Palabras clave: Aprendizaje Basado en Problemas; Pensamiento Crítico; Educación Médica; Estrategias Didácticas.

1. Introduction

Medical education, like other areas of knowledge, has undergone a transformation in recent decades in response to the social and professional demands of an increasingly complex world. It is no longer sufficient to transmit information in a unidirectional manner: it is necessary to train professionals capable of integrating knowledge, analyzing diverse realities, and responding with their own judgment to health problems that emerge in changing contexts. In this context, critical thinking has established itself as one of the essential competencies for the performance of future physicians, as it allows them to interpret situations, assess evidence, argue soundly, and make informed decisions that directly impact people's lives. Problem-Based Learning (PBL) emerged precisely with this intention. In the early 1970s, at McMaster University (Canada), a group of medical educators sought a pedagogical model that would better prepare students to face the complexity of clinical reasoning. PBL placed the student at the center of the process, challenging them with authentic problems that did not have immediate solutions, and motivating them to inquire, discuss, and collaboratively construct knowledge (1). Over time, this methodology expanded to other health science programs and, subsequently, to different disciplines in higher education, although medicine remains its most representative space.

The effectiveness of PBL has been evaluated in multiple reviews. Classic meta-analyses have shown that PBL not only promotes knowledge transfer and conceptual integration, but also improves the practical application of what has been learned in new situations. (2). However, although these studies laid solid foundations, they did not explicitly address how PBL influences the development of critical thinking, nor did they focus primarily on medical training. This omission leaves open a line of research that is especially relevant today.

The most recent literature has addressed this gap. Contemporary reviews show that PBL contributes to strengthening competencies related to clinical reasoning and decision-making in medicine (5). Additionally, an updated meta-analysis demonstrated a positive and statistically significant effect on critical thinking skills in health science students, confirming that this methodology remains a valid pedagogical strategy for training professionals (6). These findings reinforce the need to review the evidence using current criteria, taking into account changes in the educational context, the diversity of assessment instruments, and the incorporation of new technologies into learning settings. Critical thinking, understood within the Delphi–Facione framework as the articulation of skills such as interpretation, analysis, inference, explanation, evaluation, and self-regulation (7), constitutes a cross-cutting axis of contemporary medical education. It is not only a set of cognitive skills, but a constant willingness to question, contrast, and reflect on practice, with direct implications for the quality of health care. Recent studies confirm that to promote these competencies, active and student-centered methodologies are necessary, among which PBL occupies a prominent place (8).

Under these considerations, the present study aims to systematically analyze the relationship between PBL and the development of critical thinking skills in medical and health sciences students. This seeks to provide an updated and well-founded vision that guides teaching practice, contributes to curriculum design, and strengthens the training of critical and reflective professionals capable of facing the challenges of clinical practice in the 21st century. This work adopts the Delphi–Facione framework (7) as a reference to define and classify the skills (interpretation, analysis, inference, explanation, evaluation, self-regulation) and dispositions of critical thinking, a criterion used to map instruments and results.

2. Methods

Frame of reference

This systematic review was conducted following the guidelines of the 2020 PRISMA statement for systematic reviews and meta-analyses, ensuring transparency and reproducibility in the identification, screening, selection, and synthesis of included studies (9). The search protocol was developed independently by two reviewers and subsequently agreed upon; discrepancies were resolved through discussion until agreement was reached.

Search strategy

An exhaustive search was carried out in three specialized international databases: **PubMed, Scopus** and **CINAHL, selected for their** relevance in the areas of health sciences and education. The keywords used were: " *problem-based learning", "critical thinking", " didactic models"* and *"didactic models"*. The combination of terms was performed using Boolean operators: **("problem-based learning" OR "problem-based learning") AND ("critical thinking" OR "critical thinking") AND ("education" OR "educación").** The time range included articles published between **January 2000 and December 2024,** in Spanish or English and peer-reviewed.

Table 1. Search strategy and initial results

Database	Search strategy	Identified records
PubMed	("problem-based learning" OR "problem-based learning") AND ("critical thinking" OR "critical thinking") AND education	n = 25
Scopus	TITLE-ABS-KEY(("problem-based learning" OR ABP) AND ("critical thinking") AND education)	n = 38
CINAHL	("problem-based learning" AND "critical thinking" AND education)	n = 15
	Total	n = 78

Inclusion and exclusion criteria

Inclusion criteria were: empirical studies (quasi-experimental or observational) and systematic reviews/meta-analyses that evaluated PBL and measured critical thinking in medical and health education (undergraduate or graduate). Languages: Spanish/English. Exclusion criteria were narrative reviews, editorials, conference papers, book chapters, and theses.

Selection procedure

The initial search identified a total of 78 records. After eliminating 16 duplicates, 62 articles remained for initial screening. After reviewing titles and abstracts, 32 were selected for full-text reading. Of these, 14 were excluded for not meeting established criteria (topics unrelated to PBL or critical thinking, irrelevant designs, or absence of valid measurement instruments). Finally, 18 articles were included in the qualitative synthesis. The screening and selection process was conducted independently by two reviewers. Inter-rater agreement reached a kappa index of 0.82, reflecting near-perfect agreement. Discrepancies were resolved by consensus. This procedure followed the recommendations of the PRISMA 2020 declaration (9).

Coding of the results

The selected studies were analyzed under a four-dimensional coding scheme:

1. Bibliometric characteristics: authorship, year of publication, country, journal and title.
2. Methodological characteristics: design, population, sample size and critical thinking measurement instruments.
3. Intervention characteristics: PBL modality (classic or variants such as 3C3R and IDEAS), number of sessions and duration.
4. Main results: Impact of PBL on critical thinking skills, classified according to the Delphi–Facione framework (7) into interpretation, analysis, evaluation, inference, explanation and self-regulation (12).

The systematic search of the PubMed, Scopus, and CINAHL databases identified a total of 78 records. After eliminating duplicates (n = 16) and applying the inclusion and exclusion criteria, 18 articles were selected for the final qualitative analysis.

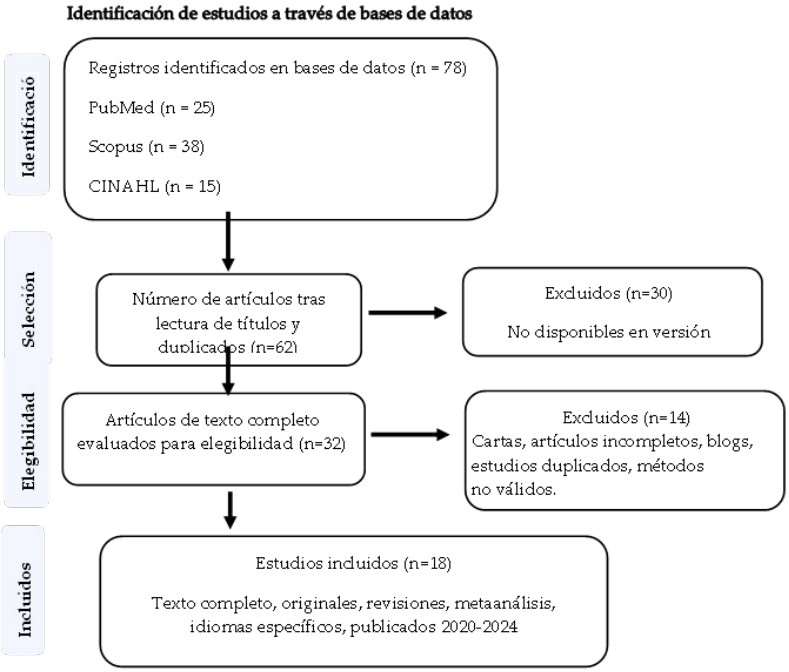

Figure 1. PRISMA flowchart used for article selection. Search strategy and selection of scientific material for the review.

The included studies were mainly developed in the field of medical and university education, with a greater representation of Latin American and European countries. The temporal distribution showed a progressive increase in publications between 2015 and 2022, which demonstrates the growing academic interest in Problem-Based Learning (PBL) and its impact on critical thinking. Regarding the bibliometric characteristics (table 2), the articles were published in indexed journals of education and health sciences, highlighting authors such as Facione (2007), who consolidated the conceptual foundations of critical thinking, and Morales (2018), who explored the direct relationship between PBL and the development of critical skills. Regarding the methodological characteristics (table 3), quasi-experimental and descriptive studies predominate, with variable sample sizes (between 95 and 423 students). The most commonly used instruments were standardized tests such as the California Critical Thinking Skills Test (CCTST) and adapted critical thinking scales. Regarding the characteristics of the intervention (table 4), two main approaches were identified:

1. Classical PBL, applied in clinical and curricular contexts.
2. Models derived from the 3C3R (Content, Context, and Connection; Reasoning, Reflection, and Inquiry) and the mnemonic IDEAS (Identify, Determine, Enumerate, Assess, Scrutinize). Intervention durations ranged from 8 to 16 weeks, with sessions ranging from 4 to 8.

In the results on critical thinking (table 5), most studies reported improvements in cognitive skills such as interpretation, analysis, evaluation and inference, as well as in attitudinal dispositions such as critical reflection, self-regulation and investigative curiosity. The findings coincide in pointing out that PBL not only promotes the acquisition of knowledge, but also boosts students' ability to make informed decisions and solve complex problems. In summary, the 18 articles reviewed show that PBL constitutes an effective pedagogical strategy to enhance critical thinking in university students, especially in health science programs, where clinical reasoning and decision-making are essential competencies.

Table 2. Bibliometric characteristics of the included studies.

Author(s)	*Year*	*Country*	*Magazine*	*Qualification*
Facione P	2007	USA	Insight Assessment	Critical Thinking: What It Is and Why It Counts
Morales P	2018	Spain	Rev Interuniv Form Prof	Problem-based learning and critical thinking
Contreras-Rodríguez	2022	Mexico	Medical Review	Development of critical thinking in

V, et al.				medical students
De la Portilla S, et al.	2019	Colombia	Rev Latinoam Estud Educ	Differences in critical thinking profiles in medical students
Cangalaya L	2020	Peru	From the South	Critical thinking skills in college students
Bugna S, Rosero M	2025	Ecuador	Rev Criteria	Developing critical thinking through PBL
Nguyen QA, Khoo HE, Durning SJ	2020	Singapore	Health Prof Educ	PBL and clinical reasoning: systematic review & meta-analysis
Turan S, Konan A	2021	Türkiye	Med Educ Online	Effect of PBL on critical thinking: a meta-analysis
Abrami PC, et al.	2015	Canada	Rev Educ Res	Strategies for students teaching to think critically: meta-analysis
Gijbels D, et al.	2005	Belgium	Rev Educ Res	Effects of PBL: meta-analysis from assessment angle
Dochy F, et al.	2003	Belgium	Learn Instr	Effects of PBL: a meta-analysis
Newman M	2003	United Kingdom	Campbell Collaboration	Effectiveness of PBL: pilot systematic review & meta-analysis
Ríos Muñoz D, et al.	2017	Brazil	Educ Pesqui	Challenges of competency-based assessment in education
Venegas Mejia VE, et al.	2019	Peru	Conrad	Educational and training research in the Peruvian university
Watty PD	2013	Mexico	Educ Profiles	Critical thinking in education
Orozco HC, et al.	2016	Spain	Faculty	Didactic models in higher education
Paul R, Elder L	2003	USA	Critical Thinking Foundation	Mini-guide to critical thinking
Hung W	2006	USA	Interdiscip J Probl Based Learn	The 3C3R model: framework for designing problems in PBL

Table 3. Research characteristics.

Author(s)	***Type of study***	***Population / sample***	***Size***	***Instruments for measuring critical thinking***
Facione P (2007)	Theoretical validation	University students	423	CCTST
Morales P (2018)	Quasi-experimental	Student pedagogy	95	Critical questionnaire, rubrics
Contreras-Rodríguez V (2022)	Cross	Medicine	180	Adapted CT scales
De la Portilla S (2019)	Comparative	Medicine	120	Adapted CT profile
Cangalaya L (2020)	Descriptive	University students	300	Analysis of cognitive skills
Bugna & Rosero (2025)	Quasi-experimental	Medicine (Latin America)	150	CCTST + rubrics
Nguyen QA (2020)	Meta-analysis	Medicine (multicenter)	15 est.	CCTST, Watson-Glaser
Turan S (2021)	Meta-analysis	Medicine/ Nursing	12 est.	CCTST
Abrami PC (2015)	Meta-analysis	Various university students	3415	Various
Gijbels D (2005)	Meta-analysis	Higher education	43 est.	Various
Dochy F (2003)	Meta-analysis	Higher education	43 est.	Various
Newman M (2003)	Pilot review system	Medicine / others	7 est.	Various
Ríos Muñoz D (2017)	Descriptive	University students	210	Scales of competences

Venegas Mejía VE (2019)	Descriptive	Peruvian university students	120	Critical questionnaire
Watty PD (2013)	Theorist	University students	-	Conceptual review
Orozco HC (2016)	Mixed study	Higher education	200	Teaching scales-CT
Paul & Elder (2003)	Theorist	University students	-	Conceptual framework
Hung W (2006)	Theorist	—	-	Proposal 3C3R

Table 4. Characteristics of the PBL intervention

Author(s)	ABP modality	Number of sessions	Duration	Applied models
Facione P (2007)	Not applicable	-	-	IDEAS
Morales P (2018)	Classroom	6	12 weeks	3C3R
Contreras-Rodríguez (2022)	Clinical	8	16 weeks	Classical PBL
De la Portilla S (2019)	Med Curriculum	5	10 weeks	Integrated PBL
Cangalaya L (2020)	Workshops	4	8 weeks	Investigative PBL
Bugna & Rosero (2025)	Clinical	6	12 weeks	Classic PBL + rubrics
Nguyen QA (2020)	System Review	-	-	Clinical PBL
Turan S (2021)	System Review	-	-	General PBL
Abrami PC (2015)	System Review	-	-	PBL + CT strategies
Gijbels D (2005)	Meta-analysis	-	-	General PBL
Dochy F (2003)	Meta-analysis	-	-	General PBL
Newman M (2003)	System Review	-	-	General PBL
Ríos Muñoz (2017)	Classroom	5	10 weeks	Transversal ABP
Venegas Mejía (2019)	Classroom	4	8 weeks	PBL + formative research
Watty PD (2013)	Theorist	-	-	Conceptual PBL
Orozco HC (2016)	Classroom	4	8 weeks	General PBL
Paul & Elder (2003)	Theorist	-	-	Critical Thinking Guide
Hung W (2006)	Theorist	-	-	3C3R

Table 5. Main results on critical thinking

Author(s)	*Improved cognitive skills*	*Provisions encouraged*	*Overall impact*
Facione P (2007)	Interpretation, analysis, evaluation	Self-regulation, critical judgment	CT framework definition
Morales P (2018)	Analysis, inference, evaluation	Critical reflection, autonomy	Significant improvement in CT
Contreras-Rodríguez (2022)	Evaluation, explanation, self-regulation.	Clinical reasoning, inquiry	CT in medicine strengthened
De la Portilla S (2019)	Inference, explanation, analysis	Investigative curiosity	Different CT profiles by methodologies
Cangalaya L (2020)	Interpretation, inference	Reflection, autonomy	PBL integrates knowledge and criticality
Bugna & Rosero (2025)	Analysis, evaluation	Critical reflection, judgment	ABP improves CT in Latin American medicine
Nguyen QA (2020)	Analysis, inference	Self-regulation	ABP improves clinical reasoning

Turan S (2021)	Interpretation, evaluation	Autonomy, critical reflection	Meta-analysis confirms CT improvement
Abrami PC (2015)	Evaluation, analysis	Questioning, inquiry	Effective CT strategies
Gijbels D (2005)	Transfer, application	-	PBL favors deep learning
Dochy F (2003)	Integrated knowledge	-	PBL improves retention and application
Newman M (2003)	Integration of knowledge	-	Positive ABP in initial medicine
Ríos Muñoz (2017)	Competency assessment	Responsibility	Skills improve with transversal PBL
Venegas Mejía (2019)	Research reflection	Autonomy, criticality	ABP strengthens research training
Watty PD (2013)	-	-	Conceptual review of CT
Orozco HC (2016)	Analysis, reflection	Collaborative work	PBL favors active methodologies
Paul & Elder (2003)	-	Systematic questioning	Practical guide for CT
Hung W (2006)	-	Problem design	Proposes 3C3R framework

4. Discussion

The findings of this systematic review reinforce the idea that Problem-Based Learning (PBL) is a particularly effective pedagogical strategy in medical education. Since its origins at McMaster University in the 1970s, PBL was designed to improve the clinical training of future physicians, and the evidence analyzed confirms that this methodology remains a key tool for developing critical competencies in professional practice (1). In line with classic meta-analyses, the reviewed studies show that PBL promotes deep learning and the transfer of knowledge to real-life clinical contexts (2-3). However, the present review provides added value by focusing on the specific relationship between PBL and critical thinking, a competency recognized today as essential for safe and quality medical practice.

Recent research in medical education shows that medical students who participate in PBL programs show significant improvements in clinical reasoning, self-regulation, and analytical skills when faced with complex health problems (4-5). These results are complemented by meta-analyses confirming a positive impact of PBL on cognitive and dispositional skills linked to critical thinking, with an emphasis on clinical decision-making and problem-solving in simulation or practice settings (6-7).

A key aspect is that PBL fosters both the mastery of cognitive skills—such as interpretation, analysis, inference, and evaluation—and attitudinal dispositions—critical reflection, investigative curiosity, and constant questioning—all of which are aligned with the Delphi–Facione framework of critical thinking (7). In medical education, these competencies not only enrich academic training but also translate into improved clinical practices by enabling students to integrate scientific knowledge with informed clinical judgment.

However, limitations were identified that should be considered. The heterogeneity of methodological designs and the diversity of instruments used to measure critical thinking (such as the California Critical Thinking Skills Test or adapted scales) make it difficult to establish direct comparisons between studies. Furthermore, although most research comes from medical and health sciences programs, there is a concentration in Latin American and European contexts, which requires multicenter and global studies to strengthen the generalizability of the evidence.

Overall, this review reaffirms that PBL is an essential pedagogical resource in contemporary medical education, promoting not only knowledge acquisition but also the development of critical thinking as a cross-curricular skill for clinical reasoning. Medical schools are encouraged to systematically integrate PBL into their curricula and support its implementation with longitudinal and comparative research that evaluates the sustained impact of this methodology on professional training.

5. Conclusions

- PBL constitutes a highly relevant methodological foundation for contemporary medical education. Its implementation fosters the development of both cognitive skills—interpretation, analysis, evaluation, inference, and self-regulation—and attitudinal dispositions oriented toward critical reflection, ongoing inquiry, and professional autonomy. These skills not only strengthen the quality of academic learning but also directly impact clinical reasoning and informed decision-making in real-life healthcare settings.
- The findings confirm that PBL transcends the framework of a specific teaching strategy, establishing itself as a training model that integrates knowledge construction with clinical judgment. By confronting students with authentic and complex problems, it promotes deep and transferable learning, essential for responding to the clinical and ethical challenges of 21st-century medical practice.
- The review also reveals limitations in the existing literature, particularly related to the heterogeneity of research designs, the diversity of measurement instruments, and the limited presence of longitudinal studies. These methodological gaps reinforce the need to promote multicenter, long-term research that allows for a more robust and generalizable assessment of the impact of PBL on critical thinking in different medical training contexts.
- In short, PBL should be considered not as an isolated resource, but as a structural component of medical curricula. Its systematic incorporation will enable the development of critical, reflective professionals capable of integrating scientific evidence with ethical and clinical judgment, ensuring more competent, humane medical practice adapted to global health challenges.

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