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Aprendizaje basado en problemas y desarrollo del pensamiento crítico en educación secundaria

Problem-based learning and the development of critical thinking in secondary education

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RESUMEN

El aprendizaje basado en problemas (ABP) promueve la indagación, la resolución de situaciones auténticas y la argumentación. El objetivo de este artículo fue analizar los aportes del ABP al desarrollo del pensamiento crítico en estudiantes de educación secundaria. Se realizó una revisión estructurada, de alcance cualitativo y descriptivo, de 16 publicaciones académicas de 2020 a 2026. Los documentos se organizaron según su contexto educativo y se sintetizaron mediante cinco ejes: pensamiento crítico, resolución de problemas, aprendizaje colaborativo y argumentación, habilidades cognitivas de orden superior y estrategias de implementación. Siete publicaciones abordaron directamente la educación secundaria, cuatro la educación superior o médica y cinco contextos mixtos. La literatura examinada relaciona el ABP con oportunidades para analizar información, justificar soluciones, evaluar evidencias y participar en actividades colaborativas. No obstante, la diversidad de diseños, poblaciones e instrumentos impide establecer un efecto único o generalizar a secundaria los resultados obtenidos en educación superior. Se concluye que el ABP constituye una alternativa pedagógica prometedora cuando incorpora problemas pertinentes, acompañamiento docente y evaluación explícita del razonamiento. La revisión es de carácter estructurado, no sistemático, debido a la ausencia de registros completos que permitan reconstruir de forma independiente la búsqueda y la selección documental.

Palabras clave: aprendizaje basado en problemas; pensamiento crítico; educación secundaria; resolución de problemas; aprendizaje activo.

ABSTRACT

Problem-Based Learning (PBL) encourages inquiry, the resolution of authentic situations, and argumentation. This article aimed to analyze the contributions of PBL to the development of critical thinking among secondary education students. A structured, qualitative, and descriptive review of 16 academic publications issued between 2020 and 2026 was conducted. The documents were organized by educational context and synthesized using five themes: critical thinking, problem-solving, collaborative learning and argumentation, higher-order cognitive skills, and implementation strategies. Seven publications directly addressed secondary education, four examined higher or medical education, and five covered mixed contexts. The literature examined associates PBL with opportunities to analyze information, justify solutions, evaluate evidence, and participate in collaborative activities. However, variation in designs, populations, and instruments prevents a single effect estimate or the generalization of higher-education findings to secondary education. The review concludes that PBL is a promising pedagogical alternative when it integrates relevant problems, teacher guidance, and explicit assessment of reasoning. This is a structured, nonsystematic review because complete records allowing independent reconstruction of the documentary search and selection were unavailable.

Keywords: problem-based learning; critical thinking; secondary education; problem-solving; active learning.



1. INTRODUCTION

The development of critical thinking is an educational priority because secondary school students increasingly need to interpret information, examine competing explanations, assess evidence, and justify decisions. Approaches based solely on the reproduction of information may provide limited opportunities to exercise these processes. Problem-Based Learning (PBL) offers a pedagogical alternative centered on inquiry, authentic problems, and collaborative reflection (Thorndahl & Stentoft, 2020; Kardoyo et al., 2020).

PBL organizes learning around an open problem that requires students to identify what they know, recognize knowledge gaps, search for information, and construct defensible responses. Teachers act as facilitators who organize appropriate tasks, guide inquiry, and assess the reasoning behind the proposed solutions. The method does not, by itself, guarantee critical thinking: outcomes depend on the design of the problem, the depth of classroom dialogue, and the assessment criteria used (Thorndahl & Stentoft, 2020).

Critical thinking, in this review, refers to interrelated cognitive processes of interpretation, analysis, evidence evaluation, inference, explanation, and reflective judgment. These dimensions are pertinent to secondary education, where students learn to weigh alternatives and defend conclusions. Yohannes et al. (2021) synthesized research on PBL and mathematical critical thinking among junior high school students, thereby connecting this instructional approach to a clearly defined school-level outcome.

Within science and mathematics instruction, problem-based activities can require learners to interpret unfamiliar situations, formulate hypotheses, and compare possible solutions. Akhdinirwanto et al. (2020) examined the incorporation of argumentation into PBL among junior high school students. Affandy et al. (2024) evaluated the integration of creative pedagogy and PBL in science education, focusing on higher-order thinking. Together, these studies illustrate that reasoning must be intentionally embedded in instructional tasks.

Direct evidence from secondary education is especially relevant. Andrianto and Qodr (2025) investigated PBL among eighth-grade students using a quasi-experimental design and a comparison with conventional instruction. Nicholus et al. (2024) studied video-based PBL among secondary school students in Uganda. Muñoz Vélez et al. (2026) examined PBL in Ecuadorian high school Social Sciences. These investigations situate PBL in different



subjects and instructional settings, limiting the appropriateness of assuming a single mode of implementation.

Collaboration is another component of PBL because students can explain their thinking, challenge interpretations, and negotiate evidence-based conclusions. Sappaile et al. (2025) addressed analytical thinking and collaborative learning in junior high school. However, simply placing students in groups does not ensure that they analyze evidence or evaluate arguments; teachers must organize discussion and reflection around explicit learning objectives (Thorndahl & Stentoft, 2020).

Broader research offers useful but not directly transferable context. Erdem (2024) synthesized the effects of PBL on cognitive outcomes across K–12 education, while Anggraeni et al. (2023), Garil and Dio (2024), and Hafizah et al. (2024) reviewed PBL in heterogeneous educational settings. Liu and Pásztor (2022) assessed critical thinking outcomes in higher education, and Manuaba et al. (2022) analyzed critical thinking, problem-solving, and self-directed learning in medical education. These bodies of evidence clarify potential mechanisms and variations but cannot substitute for evidence specific to adolescents.

Existing literature differs in its operational definitions of critical thinking, duration and content of interventions, educational populations, and outcome measures. Evidence syntheses are also sometimes discussed alongside primary interventions without distinguishing the nature of their contributions. A focused comparison that foregrounds secondary education while explicitly separating other populations can therefore make the instructional implications clearer.

Accordingly, this article analyzes the contributions of Problem-Based Learning to the development of critical thinking in secondary education, drawing on academic publications from 2020 to 2026. The guiding question is: What does the examined literature indicate about the relationship between PBL and critical thinking in secondary school students, and under what instructional conditions are these contributions described?

2. METHODOLOGY



Review design and scope

A structured literature review was conducted using a qualitative, descriptive, and interpretive approach. Its purpose was to compare documented educational findings concerning PBL, critical thinking, problem-solving, argumentation, collaborative work, and related higher-order cognitive skills. The review corpus comprised the 16 publications explicitly identified in the source manuscript, published between 2020 and 2026. The documentary consultation cutoff reported in the original manuscript was September 22, 2026.

This study is described as a structured, nonsystematic review rather than a systematic review or meta-analysis. The original manuscript did not provide retrievable search histories, database exports, complete deduplication logs, or independently auditable exclusion decisions. Consequently, database-specific record counts, a PRISMA flow diagram, and numerical quality scores are not presented as verified methodological findings. This approach preserves the analyzable documentary evidence without attributing undocumented procedures to the authors.

Documentary corpus and relevance criteria

The corpus was defined by the 16 studies listed in Table 1. Publications were considered relevant when they directly addressed PBL or analyzed associated critical thinking, problem-solving, argumentation, higher-order thinking, or instructional design outcomes. Sources published from 2020 to 2026 and available in English or Spanish formed the temporal and linguistic scope of the analysis. The collection includes empirical interventions, quasi-experimental investigations, conceptual reviews, systematic reviews, and meta-analyses.

Sources were grouped by the educational context reported in the source manuscript: seven publications directly relating to secondary education, four relating to higher or medical education, and five addressing mixed or broader educational settings. These categories describe the documentary corpus, not the prevalence or effectiveness of PBL in the wider research literature. Some review studies combine several educational levels and therefore cannot provide an independent secondary-only effect estimate.

Studies involving secondary school students were treated as the principal evidence for answering the research question. Research involving university or medical students was discussed only for conceptual or comparative purposes. Primary investigations and reviews



of primary studies were not counted as independent demonstrations of effects, because their underlying evidence could overlap.

Data extraction and synthesis

For the descriptive synthesis, the available bibliographic and study-characterization information was organized by authorship and publication year, educational context, design, thematic focus, and relevance to critical thinking. The comparison used five analytical themes: (1) PBL and critical thinking; (2) problem-solving skills; (3) collaborative learning and argumentation; (4) cognitive development and higher-order thinking; and (5) pedagogical implementation in secondary education.

The synthesis compared the direction and educational interpretation of reported findings while distinguishing direct secondary-education evidence from findings in other populations. No pooled effect size, statistical significance test across studies, inter-rater agreement estimate, or quantitative quality ranking was calculated. Interpretations were constrained to the characteristics and findings stated in the cited publications; missing information was not reconstructed from assumptions.

3. RESULTS

The corpus included 16 publications distributed across three educational-context groups: seven addressing secondary education directly (43.75%), four examining higher or medical education (25.00%), and five spanning mixed or broader contexts (31.25%). The distribution reflects the classifications contained in the documentary material and serves only to characterize these 16 sources. The articles varied in research design, discipline, and the types of outcomes assessed.

Table 1.

Characteristics of the 16 publications considered in the documentary synthesis

Publication	Educational context	Design	Focus and reported contribution
Akhdinirwanto et al. (2020)	Secondary	Educational intervention	PBL and argumentation; examines critical thinking through argumentation-based activities.



Publication	Educational context	Design	Focus and reported contribution
Kardoyo et al. (2020)	Higher education	Classroom action research	Critical and creative thinking; examines PBL in university-level learning activities.
Thorndahl & Stentoft (2020)	Higher education	Scoping review	Critical thinking and PBL; analyzes conceptual relationships between PBL and critical thinking.
Yohannes et al. (2021)	Secondary	Meta-analysis	Mathematical critical thinking; synthesizes evidence on mathematical critical thinking.
Liu & Pásztor (2022)	Higher education	Meta-analysis	PBL effectiveness; examines PBL interventions and critical thinking.
Manuaba et al. (2022)	Medical education	Meta-analysis	Cognitive competencies; examines critical thinking, problem-solving, and self-directed learning.
Anggraeni et al. (2023)	Mixed / K–12	Systematic review	PBL and critical thinking; synthesizes findings on critical thinking development.
Erdem (2024)	Mixed / K–12	Meta-analysis	Cognitive learning outcomes; examines cognitive outcomes associated with PBL.



Publication	Educational context	Design	Focus and reported contribution
Garil & Dio (2024)	Mixed / K–12	Systematic review	Problem-solving and critical thinking; examines critical thinking and problem-solving.
Hafizah et al. (2024)	Mixed / K–12	Meta-analysis	PBL and critical thinking; synthesizes effects on students' critical thinking.
Nicholus et al. (2024)	Secondary	Educational intervention	Video-based PBL; examines critical thinking-related performance and motivation.
Affandy et al. (2024)	Secondary	Quasi-experimental study	Creative pedagogy and PBL; examines higher-order thinking skills.
Andrianto & Qodr (2025)	Secondary	Quasi-experimental study	Critical thinking and problem-solving; compares PBL and conventional instruction among 64 students.
Cinthia et al. (2025)	Mixed / K–12	Meta-analysis	PBL effectiveness; examines educational outcomes associated with PBL.
Sappaile et al. (2025)	Secondary	Educational investigation	PBL implementation; examines analytical thinking and collaborative learning.



Publication	Educational context	Design	Focus and reported contribution
Muñoz Vélez et al. (2026)	Secondary	Educational intervention	PBL and critical thinking in Social Sciences; examines critical thinking in Ecuadorian secondary education.

Note. The entries summarize the 16 references included in the source manuscript. Educational-context labels do not imply equivalence of populations or independent effect estimates.

PBL and critical thinking

The central theme concerns opportunities to interpret information, examine alternatives, evaluate evidence, and justify conclusions. Among secondary-school populations, Yohannes et al. (2021) analyzed mathematical critical thinking, while Andrianto and Qodr (2025) investigated critical thinking and problem-solving in eighth-grade students. Muñoz Vélez et al. (2026) examined the use of PBL in high school Social Sciences. These sources support consideration of PBL as an instructional context in which reasoning can be made visible and assessed.

At the conceptual level, Thorndahl and Stentoft (2020) emphasized the need to specify what counts as critical thinking and how learning activities are expected to develop it. Research syntheses involving higher education or multiple educational levels (Liu & Pásztor, 2022; Anggraeni et al., 2023; Hafizah et al., 2024) offer converging perspectives, but the populations and interventions differ from those of secondary-only investigations.

Problem-solving and reflective judgment

Problem-solving activities require the identification of relevant information, formulation of hypotheses, assessment of alternatives, and defense of plausible solutions. Andrianto and Qodr (2025) explicitly examined both problem-solving and critical thinking at the junior high school level. Garil and Dio (2024) synthesized these two outcomes across the studies included in their review.

The medical-education synthesis by Manuaba et al. (2022) addresses related competencies in a different population and was considered comparative evidence only. Differences



between school and medical education highlight why instructional duration, prior knowledge, and outcome instruments should be considered before drawing broad conclusions about PBL effectiveness.

Collaborative learning and argumentation

PBL can create occasions for students to compare viewpoints, defend interpretations, and revise their reasoning. Akhdinirwanto et al. (2020) focused on a PBL model incorporating argumentation in junior high school, while Sappaile et al. (2025) examined critical thinking alongside analytical and collaborative learning. These studies indicate that discussion and evidence-based explanation are relevant components of active classroom tasks.

The interpretive implication is that collaboration should be organized around a problem requiring justified decisions rather than treated as a benefit that follows automatically from group work. Structured guidance, explicit argumentation criteria, and opportunities for individual reflection remain essential considerations (Thorndahl & Stentoft, 2020).

Cognitive development and higher-order thinking

Affandy et al. (2024) investigated creative pedagogy incorporated into PBL in science education, with higher-order thinking skills as a principal outcome. Erdem (2024) provided a broader K–12 synthesis of cognitive outcomes, while Kardoyo et al. (2020) addressed critical and creative thinking in higher education. The constructs considered across these sources partially overlap but are not identical to critical thinking.

Accordingly, improvements in creativity, academic performance, or generalized cognitive outcomes cannot be interpreted automatically as measured improvements in critical thinking. Differences in instruments and research designs make careful definition of the target skill particularly important.

Pedagogical implementation in secondary education

The reviewed secondary-school publications illustrate different modes of PBL implementation. Nicholus et al. (2024) studied a video-based approach, whereas Muñoz Vélez et al. (2026) discussed activities situated in Social Sciences. Andrianto and Qodr (2025) considered a quasi-experimental classroom comparison, and Akhdinirwanto et al. (2020) placed particular emphasis on argumentation.

Across these contexts, a consistent instructional rationale is the use of authentic and cognitively demanding problems, supported inquiry, collaborative examination of



alternatives, and assessment aligned with analytical reasoning. The evidence does not establish that any single implementation strategy is universally superior; rather, it highlights the importance of a match between problem design, student characteristics, and intended learning outcomes.

Table 2.

Thematic synthesis and evidence traceability

Analytical theme	Described processes	Illustrative sources	Interpretive boundary
Critical thinking	Interpretation, evidence evaluation, justified judgment	Yohannes et al. (2021); Andrianto & Qodr (2025); Muñoz Vélez et al. (2026)	Secondary studies are primary; cross-level reviews provide context.
Problem-solving	Hypothesis formulation, comparison of solutions, reflective decisions	Andrianto & Qodr (2025); Garil & Dio (2024); Manuaba et al. (2022)	Medical findings are not generalized to adolescents.
Collaboration and argumentation	Discussion, defense of claims, peer evaluation	Akhdinirwanto et al. (2020); Sappaile et al. (2025); Thorndahl & Stentoft (2020)	Teacher guidance is relevant; participation alone is insufficient.
Higher-order thinking	Creativity, analysis, evaluation, reflection	Affandy et al. (2024); Erdem (2024); Kardoyo et al. (2020)	Related cognitive outcomes are not identical to critical thinking.
Implementation	Authentic tasks, disciplinary contexts, digital resources, feedback	Nicholus et al. (2024); Muñoz Vélez et al. (2026); Andrianto & Qodr (2025)	Findings depend on discipline, instructional design, and instruments.

Note. Sources may inform more than one theme. The table is a qualitative synthesis, not a tally of statistically significant effects.

Taken together, the publications indicate that PBL can furnish conditions in which reasoning becomes part of the learning process. The clearest direct relevance to the research question comes from studies involving secondary students, particularly those analyzing critical thinking or closely defined cognitive competencies. However, the collection contains diverse study types and overlapping constructs; therefore, it does not support a pooled numerical



estimate of impact, universal causal claims, or the assumption that results will be identical in all secondary classrooms.

4. DISCUSSION

The reviewed literature points toward an educationally plausible association between PBL and critical thinking: problems that require inquiry and evidence-based decisions invite the processes that critical thinking assessments intend to capture. However, this interpretation needs to distinguish between opportunities provided by a teaching model and evidence of measured improvements. The presence of authentic problems, collaboration, or technology does not demonstrate an improvement unless the target competency is operationally defined and assessed.

The publications concerned directly with secondary education supply the strongest contextual relevance. Yohannes et al. (2021) considered mathematical critical thinking in junior high school, and Andrianto and Qodr (2025) studied both critical thinking and problem-solving among eighth-grade students. These works are particularly relevant because they align the educational population with the article's research question. The Ecuadorian high school study by Muñoz Vélez et al. (2026) extends the discussion to Social Sciences, suggesting that PBL can be considered beyond mathematics or experimental sciences.

A second contribution concerns the instructional mechanisms. Akhdinirwanto et al. (2020) highlighted argumentation, while Sappaile et al. (2025) addressed collaboration and analytical thinking. These processes may reinforce one another: students must interpret a problem before proposing an explanation, and defending that explanation to peers can reveal weaknesses in its underlying assumptions. Nevertheless, group interaction alone cannot be equated with reasoned judgment. As Thorndahl and Stentoft (2020) argue conceptually, explicit definitions and tasks are required to connect PBL to critical thinking.

Technology and creative pedagogy broaden possible designs but also complicate the interpretation of effectiveness. Nicholus et al. (2024) investigated a video-based PBL approach, whereas Affandy et al. (2024) examined higher-order thinking in a creativity-oriented science intervention. If an intervention changes multiple instructional components simultaneously, reported outcomes cannot always be attributed exclusively to the problem-



based element. Moreover, reasoning, creativity, academic performance, and motivation should be differentiated rather than treated as interchangeable outcomes.

The wider syntheses help contextualize the literature but do not override population boundaries. Erdem (2024) considered K–12 cognitive outcomes, whereas Liu and Pásztor (2022) focused on higher education and Manuaba et al. (2022) on medical education. The results of these studies are informative for understanding potential mechanisms and heterogeneity, yet adolescents differ from university students in prior knowledge, curricular expectations, and learning environments. The systematic reviews by Anggraeni et al. (2023) and Garil and Dio (2024), as well as the meta-analyses by Hafizah et al. (2024) and Cinthia et al. (2025), should also not be treated as independent primary classroom interventions.

For teaching practice, the synthesis supports a cautious set of implications. Problems should connect to disciplinary objectives and be sufficiently open to encourage multiple justified approaches. Instructional scaffolding can assist learners with source evaluation and hypothesis formulation without replacing student reasoning. Collaborative stages should require explicit justification of claims, and assessment should measure the intended dimensions of critical thinking rather than only completion of an assignment. Such recommendations are derived from the instructional themes of the reviewed literature and should not be interpreted as universally demonstrated causal effects.

This review has substantive methodological limitations. The manuscript's source material identifies 16 publications but does not include the complete search exports, deduplication records, full-text exclusion decisions, or evidence supporting the proposed numerical quality scores. The review was therefore reported as a structured, nonsystematic documentary synthesis, and unverifiable PRISMA figures and quality rankings were omitted. Furthermore, empirical studies, meta-analyses, and conceptual work differ substantially in design and evidentiary weight, and their underlying primary studies may overlap. No pooled effect size or formal risk-of-bias conclusion can be derived from the available information. The 16-publication corpus should therefore not be presented as an exhaustive representation of the field.

Future research should prioritize transparent search and eligibility documentation, distinguish secondary-only samples, describe the duration and pedagogical components of PBL interventions, and report critical thinking outcomes using clearly defined



instruments. Where feasible, comparable baseline measurements and appropriately designed control conditions would support stronger estimates of the magnitude and durability of educational change.

5. CONCLUSION

The structured documentary review indicates that Problem-Based Learning offers relevant opportunities to develop critical thinking in secondary education by engaging students in the interpretation of problems, examination of evidence, evaluation of alternatives, and justification of solutions. The available secondary-school studies provide a more pertinent basis for this conclusion than findings from higher or medical education.

Problem-solving, collaboration, and argumentation emerged as connected but distinguishable elements of PBL. Their educational value depends on tasks that demand reasoning, explicit teacher guidance, and formative assessment directed at the target competencies. Neither collaborative participation nor the adoption of a problem-based format, by itself, guarantees measurable improvement in critical thinking.

The reviewed corpus contains seven publications directly associated with secondary education, four with higher or medical education, and five with mixed contexts. This classification underscores the importance of separating results by educational population and of avoiding causal generalizations from heterogeneous designs. The synthesis cannot establish a uniform effect size or demonstrate that every PBL implementation produces equivalent learning gains.

For secondary education, the principal implication is to design authentic, discipline-appropriate problems supported by inquiry, argumentation, feedback, and explicit criteria for evaluating reasoning. More rigorous primary studies and fully reproducible reviews are needed to clarify the conditions, magnitude, and consistency of the relationship between PBL and critical thinking development.

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CONFLICT OF INTEREST

None.

CONFLICT OF INTEREST

Not applicable.

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