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Instructional Design for Problem-Based Learning in Mathematics Education: A Descriptive Evidence-Mapping Review

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ABSTRACT

Purpose: This study mapped problem-based learning (PBL) instructional configurations in mathematics education and the cognitive and affective outcomes examined across educational levels.

Methods: A descriptive evidence-mapping review used a previously assembled 2015–2023 literature inventory identified through Scopus, Google Scholar, and Publish or Perish. The reported selection process contained 39 entries. Because complete search strings, the final search date, and stage-specific exclusion reasons were unavailable, these details were not reconstructed. A source-level scope audit excluded four entries whose mathematics relevance could not be established confidently, leaving 35 studies for analysis.

Findings: The analytical set comprised five elementary, 15 junior high school, 11 senior high school, and four higher education studies. Configurations included PBL without a named additional approach, culturally contextualized designs, technology-supported formats, and strategy-linked arrangements. Outcomes included problem solving, critical thinking, mathematical literacy, communication, retention, motivation, and self-efficacy; comparator advantages and nonsignificant affective findings were also present.

Research Implications: The synthesis supports explicit alignment among problem tasks, instructional supports, comparators, and assessment, while avoiding claims of uniform PBL superiority.

Originality: The review connects educational level, instructional configuration, and outcome domain in a common descriptive map while making limitations in the available review record explicit.

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INTRODUCTION

Problem-based learning (PBL) organizes instruction around meaningful problems, yet the label PBL alone does not explain how a mathematics lesson is designed or how learning is supported. Schettino (2016) frames mathematical PBL as a relational pedagogy in which mathematical activity and classroom relationships are considered together. Ramadhani, Huda, et al. (2019) likewise discuss PBL as an educational approach whose use requires attention to how problems, learning activities, and support are organized. These perspectives make instructional design central to interpreting reported outcomes rather than treating it as a preliminary administrative step. The relevant question is therefore not simply whether PBL is used, but how its instructional configuration relates to the mathematical competency being examined.

The empirical literature addresses different mathematical needs across educational levels. Elementary studies examine achievement, mathematical literacy, problem solving, and critical thinking, as illustrated by Mulyanto et al. (2018), Fery et al. (2017), and Ahdhianto et al. (2020). At the secondary level, studies consider mathematical communication, self-regulated learning, reasoning, and problem solving (Napitupulu et al., 2016; Surya et al., 2018). Higher education studies examine critical thinking through number theory, mathematical problem posing, and other university mathematics contexts (Aini et al., 2019; Darhim et al., 2020; Zetriuslita et al., 2017). These differences make a general statement that PBL improves mathematical ability too imprecise to explain what was taught, assessed, or achieved.

Instructional conditions further complicate interpretation. Al Said et al. (2019) investigated primary mathematics teachers' beliefs and practices, providing implementation evidence rather than a controlled estimate of student achievement. At the university level, Rattanatumma and Puncreobutr (2016) compared PBL with Student Teams Achievement Divisions (STAD), with the reported comparison favoring STAD. Zetriuslita et al. (2017) found a difference in mathematical critical thinking but no significant between-group difference in mathematical curiosity. These studies address different questions and therefore should not be treated as interchangeable demonstrations of PBL effectiveness.

The range of PBL configurations creates a practical need for a design-oriented synthesis. Peranginangin et al. (2019) developed learning materials using a Karo cultural context, whereas Siagian et al. (2019) developed PBL-oriented materials targeting problem solving and metacognition. Technology-related configurations included flipped PBL integrated with Google Classroom and mobile blended PBL (Amin et al., 2021; Ramadhani, Umam, et al., 2019). These arrangements combine PBL with different contextual, material, and technological supports. A design-focused review can therefore help identify instructional possibilities without assuming that the same configuration is appropriate in every mathematics classroom.

Previous studies provide substantial evidence on particular outcomes, but their targets, designs, and comparators vary. Elementary investigations focus on learning outcomes and literacy (Fery et al., 2017; Kaharuddin, 2018; Mulyanto et al., 2018), while secondary studies emphasize problem solving, communication, and self-confidence (Amalia et al., 2017; Hendriana et al., 2018; Perwitasari & Surya, 2017). Other studies consider critical thinking, retention, and higher-order thinking (Ajai & Imoko, 2015; Arifin et al., 2020; Surya & Syahputra, 2017). Comparisons with realistic mathematics education, discovery learning, and open-ended learning further broaden the instructional alternatives under consideration (Susanti & Rustam, 2018; Tanjung et al., 2020). This diversity supports descriptive mapping but prevents a simple ranking of PBL across contexts.

The synthesis problem is therefore narrower than asking whether PBL has been studied before. Suparman et al. (2021) focused their meta-analysis on mathematical problem solving among Indonesian students, whereas the present review considers multiple outcome domains and educational levels. Individual studies of mobile blended learning, flipped learning, and critical thinking remain tied to particular instructional arrangements (Amin et al., 2021; Darhim et al., 2020; Ramadhani, Umam, et al., 2019). Reading these findings together requires distinguishing combined interventions from comparisons between separate teaching approaches. The contribution of the present review is a descriptive integration of educational level, named design features, and assessed competencies rather than a claim that no prior PBL review exists.

Treating instructional configuration as an analytical unit is particularly important when the same PBL label refers to substantially different classroom arrangements. In the mapped literature, cultural framing changes the context in which a mathematical problem is encountered, digital tools alter access to resources or the sequence of participation, and learning-material development determines how tasks and supports are packaged for use. Peranginangin et al. (2019), Wardono et al. (2016), Ramadhani, Umam, et al. (2019), and Amin et al. (2021) illustrate these differences. Their studies should not be collapsed into a single treatment category when the instructional components, technological supports, and intended competencies are not equivalent. A descriptive map is therefore useful for identifying what was actually combined with PBL and for preventing an intervention label from obscuring design decisions that may be relevant to interpretation.

A second reason for mapping rather than ranking the literature is the variation in evidence type. The inventory includes experimental comparisons, development studies, implementation-oriented work, and conference proceedings, while the assessed outcomes range from achievement and problem solving to motivation, self-efficacy, curiosity, and self-regulation. These forms of evidence answer different questions and do not carry the same inferential weight. For example, an implementation study can describe how teachers perceive or enact PBL, whereas a comparative experiment can address differences between instructional conditions; neither should automatically be interpreted as evidence for every other outcome. Likewise, the presence of an affective or cognitive variable in a study does not imply statistically significant improvement. This distinction is central to the present review because its contribution lies in clarifying the relationship among design, context, and outcome rather than producing a pooled estimate of effectiveness.

This study aimed to describe PBL instructional designs in mathematics education and the competencies addressed in studies published from 2015 to 2023. The analysis focused on reported configurations across elementary, junior high school, senior high school, and higher education contexts and on the cognitive and affective domains associated with those configurations. Because the available review record did not preserve all information required for a fully reproducible systematic review, the study is presented as a descriptive evidence-mapping review. Its intended contribution is to connect design choices with outcome domains in a way that can inform lesson planning and more explicit reporting of future interventions. No pooled estimate of effectiveness or developmental sequence across educational levels is claimed.

METHOD

Research design and scope

This study used a descriptive evidence-mapping review to examine PBL instructional configurations and reported competencies in mathematics education. The review drew on an existing literature inventory covering publications from 2015 to 2023 and educational settings from elementary school through higher education. Published research reports, rather than newly recruited participants, were the units of analysis. The available review record documented identification, screening, full-text assessment, and inclusion counts, but it did not contain a prospective protocol or enough information to reproduce every search and screening decision. Accordingly, the present analysis emphasizes transparent descriptive mapping rather than claims of complete systematic-review reproducibility.

Information sources and search

The available review record identified Scopus, Google Scholar, and Publish or Perish as information sources. Search terms concerned PBL instructional design in mathematics learning and the four educational levels, and the phrase "Problem Based Learning in Mathematical Learning" was also recorded. The database queried through Publish or Perish, exact database-specific search strings, search fields, language restrictions, source-specific retrieval counts, and the final search date were not preserved in the available materials. These details are therefore reported as unavailable rather than reconstructed. The 2015–2023 interval refers to the publication window represented in the inventory and should not be interpreted as the dates on which searching was conducted.

Eligibility and study selection

For the present synthesis, eligibility was defined by topical scope: a report had to address PBL in mathematics learning or mathematics education within the 2015–2023 publication window and provide information relevant to instructional configuration or an assessed outcome. Because the purpose was descriptive mapping rather than effect estimation, publication type and study design were treated as descriptive characteristics rather than exclusion criteria within the available inventory; consequently, journal articles, conference proceedings, experimental studies, development studies, and implementation studies could be represented. The reported review flow comprised 186 identified records, 133 records after duplicate removal, 63 full-text reports assessed, and 39 entries in the original inventory. A source-level scope audit excluded four entries from the mathematics-focused analytical set: Sihaloho et al. (2017), which concerned physics; LaForce et al. (2017), which examined PBL and STEM career interest rather than mathematics instruction; Alt et al. (2023), which examined digital concept mapping in higher education without a mathematics-specific instructional context; and Malmia et al. (2019), whose source description used inconsistent disciplinary wording and therefore could not be classified confidently as mathematics instruction. The resulting analytical set contained 35 studies. The available materials did not preserve the original stage-specific exclusion reasons, so those reasons are not reconstructed here.

2.4 Data extraction and organization

Data were organized by educational level, instructional configuration, outcome domain, publication year, and publication venue. Where the source description allowed, study design or publication type was also noted to prevent experimental, development, implementation, and conference reports from being interpreted as equivalent forms of evidence. The study inventory was then grouped into elementary, junior high school, senior high school, and higher education tables. No separate extraction form, duplicate extraction record, reviewer-assignment log, or documented procedure for resolving coding disagreements was available. Consequently, the tables should be read as a structured descriptive map of the available study reports rather than an independently replicated coding exercise.

2.5 Synthesis and methodological quality

The synthesis proceeded through iterative extraction, condensation, tabulation, and cross-study comparison. Studies were compared within and across educational levels according to instructional configuration and the cognitive or affective domain examined. No pooled effect sizes, statistical heterogeneity analysis, or study-level weighting were performed. A formal risk-of-bias or methodological-quality appraisal was not documented in the available review record and is therefore not reported. These limitations mean that the review can describe patterns in the literature and identify design possibilities, but it cannot support comparative estimates of intervention effectiveness or a hierarchy of PBL configurations.

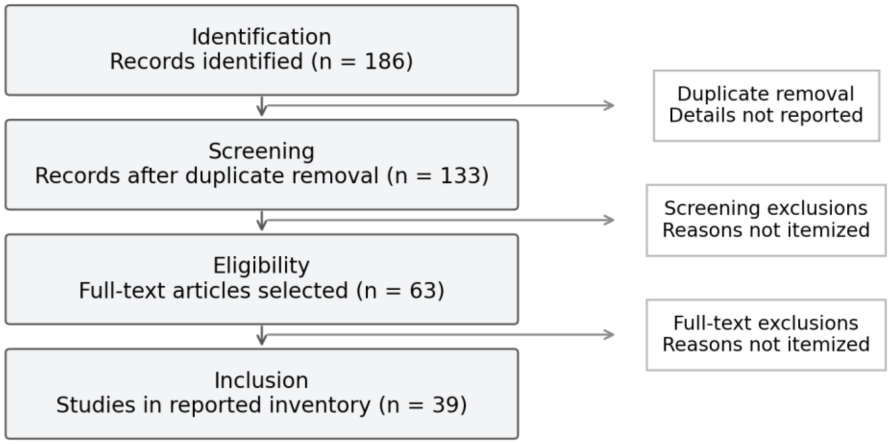

Figure 1. Reported study-selection flow

Note. The counts reproduce the available review record up to the 39-entry inventory. Stage-specific exclusion reasons were not preserved. A subsequent source-level scope audit for the present synthesis excluded four entries whose mathematics relevance could not be established confidently, yielding a 35-study analytical set.

RESULTS

The reported inventory contained 39 entries. Source-level scope checking excluded four reports whose mathematics relevance could not be established confidently, leaving 35 studies in the analytical set: five at elementary level, 15 at junior high school level, 11 at senior high school level, and four in higher education. Tables 1–4 describe the mathematics-focused studies by instructional configuration, outcome domain, year, and publication venue. Outcome columns indicate what was examined and should not be read as evidence that every reported outcome improved significantly. Because publication type and study design varied, the results are interpreted as a descriptive map rather than a pooled estimate of PBL effectiveness.

3.1 Elementary mathematics education

The five elementary entries addressed mathematics learning outcomes, literacy, problem solving, critical thinking, and implementation-related engagement. Four entries described PBL without a named additional instructional approach (Ahdhianto et al., 2020; Fery et al., 2017; Kaharuddin, 2018; Mulyanto et al., 2018). This description does not establish that their lessons lacked scaffolding, contextual adaptation, or other forms of support. Al Said et al. (2019) provided qualitative evidence about teachers' beliefs and practices in Qatari primary schools. Accordingly, that study is interpreted as implementation evidence rather than experimental evidence of student learning outcomes.

Table 1. Reported PBL study inventory in elementary education

No.	Study and instructional configuration	Outcome domain examined	Year	Publication venue
1	Mulyanto et al. (2018). PBL on geometric properties, congruence, and symmetry.	Mathematics learning outcomes	2018	International Journal of Educational Research Review
2	Kaharuddin (2018). PBL in grade 6 elementary mathematics.	Mathematics learning outcomes	2018	International Journal of Trends in Mathematics Education Research
3	Fery et al. (2017). PBL in grade 5 elementary mathematics.	Mathematical literacy	2017	Educational Research and Reviews
4	Ahdhianto et al. (2020). PBL in grade 5 elementary mathematics.	Problem solving; critical thinking	2020	Universal Journal of Educational Research
5	Al Said et al. (2019). PBL implementation in Qatari primary schools; qualitative teacher study.	Teacher beliefs and practices; perceived learning and engagement	2019	EURASIA Journal of Mathematics, Science and Technology Education

Note. Outcome domains indicate what was examined and do not by themselves imply statistically significant improvement. Al Said et al. (2019) is an implementation study based on teachers' beliefs and practices rather than an experimental student-outcome study.

3.2 Junior high school mathematics education

The 15 junior high school entries covered problem solving, mathematical communication, conceptual understanding, literacy, critical thinking, metacognition, resilience, motivation, self-efficacy, and self-regulated learning. Named designs included culturally contextualized materials, Course Review Horay, flipped learning with Google Classroom, and the Indonesian Realistic Mathematics Education approach (PMRI) with Edmodo (Malasari et al., 2017; Peranginangin et al., 2019; Ramadhani et al., 2020; Wardono et al., 2016). Development of PBL-oriented materials was also represented (Perwitasari & Surya, 2017; Siagian et al., 2019). Hafiz et al. (2017) compared PBL with guided discovery, so guided discovery is treated as a comparator rather than as a component integrated into PBL. The range of study designs and outcome domains supports descriptive comparison but not a single common-effect interpretation.

Table 2. Reported PBL study inventory in junior high school

No.	Study and instructional configuration	Outcome domain examined	Year	Publication venue
1	Simamora et al. (2017). PBL on social arithmetic.	Problem solving	2017	International Journal of Sciences: Basic and Applied Research
2	Botty et al. (2016). PBL in a Year 9 mathematics classroom in Brunei Darussalam.	Learning motivation	2016	International Research in Education
3	Surya et al. (2018). PBL in grade 8 mathematics.	Mathematical communication; self-regulated learning	2018	Journal of Education and Practice
4	Ahamad et al. (2018). PBL in geometry lessons in Brunei Darussalam.	Student performance	2018	Journal of Physics: Conference Series [proceedings]
5	Peranginangin et al. (2019). PBL materials using a Karo cultural context (PBL-KCC) in grade 7.	Problem solving; self-efficacy	2019	International Electronic Journal of Mathematics Education
6	Perwitasari and Surya (2017). PBL-based materials; statistics context reported in the inventory.	Mathematical communication	2017	International Journal of Sciences: Basic and Applied Research
7	Amalia et al. (2017). PBL in junior high school mathematics.	Problem solving	2017	International Journal of Advance Research and Innovative Ideas in Education
8	Siagian et al. (2019). Development of PBL-oriented learning materials.	Problem solving; metacognition	2019	International Electronic Journal of Mathematics Education
9	Hafiz et al. (2017). Comparison of PBL and guided discovery.	Mathematical resilience	2017	Journal of Physics: Conference Series [proceedings]
10	Eviyanti et al. (2017). PBL in grade 7 mathematics.	Problem solving	2017	International Journal of Novel Research in Education and Learning
11	Malasari et al. (2017). PBL with Course Review Horay.	Mathematical connections	2017	Journal of Physics: Conference Series [proceedings]
12	Astriani et al. (2017). PBL on the Pythagorean theorem in grade 8 MTs, as recorded in the inventory.	Problem solving	2017	International Journal of Advance Research and Innovative Ideas in Education
13	Yuniara and Surya (2017). PBL in grade 8 MTs mathematics.	Mathematical conceptual understanding	2017	International Journal of Sciences: Basic and Applied Research
14	Ramadhani et al. (2020). Flipped PBL using LMS–Google Classroom for statistics.	Mathematical critical thinking	2020	Journal of Physics: Conference Series [proceedings]
15	Wardono et al. (2016). PBL with PMRI and Edmodo.	Mathematical literacy	2016	Journal of Physics: Conference Series [proceedings]

Note. Outcome domains indicate what was examined and do not by themselves imply statistically significant improvement. The table includes journal articles and conference proceedings as part of the descriptive evidence map.

3.3 Senior high school mathematics education

The 11 mathematics-focused senior high school entries included achievement, problem solving, critical thinking, mathematical reasoning, retention, self-confidence, statistical thinking, and higher-order thinking. Named configurations included GeoGebra-related instruction, flipped PBL with Google Classroom, and mobile blended PBL (Amin et al., 2021; Ramadhani & Narpila, 2018; Ramadhani, Umam, et al., 2019). Arifin et al. (2020) compared PBL with multimedia-assisted direct instruction across cognitive styles; multimedia assistance should therefore be attributed to the comparator rather than automatically to the PBL condition. Three reports in the original senior-high inventory were excluded from the mathematics-focused synthesis: Sihaloho et al. (2017), because the source content addressed physics; LaForce et al. (2017), because it addressed broader STEM career interest rather than mathematics instruction; and Malmia et al. (2019), because inconsistent disciplinary wording prevented confident classification as mathematics instruction. The remaining entries are interpreted according to their specific design and outcome rather than as interchangeable evidence of PBL effectiveness.

Table 3. Reported PBL study inventory in senior high school

No.	Study and instructional configuration	Outcome domain examined	Year	Publication venue
1	Ramadhani and Narpila (2018). Local-culture PBL supported by GeoGebra.	Statistical thinking	2018	International Journal of Engineering & Technology
2	Ramadhani, Umam, et al. (2019). Flipped PBL integrated with LMS–Google Classroom.	Mathematical ability	2019	Journal for the Education of Gifted Young Scientists
3	Arifin et al. (2020). PBL compared with multimedia-assisted direct instruction across cognitive styles.	Critical thinking; mathematics retention	2020	Journal of Technology and Science Education
4	Widyatiningtyas et al. (2015). PBL in senior high school mathematics.	Mathematical critical thinking	2015	Journal on Mathematics Education
5	Ajai and Imoko (2015). PBL in algebra.	Mathematics achievement; retention	2015	International Journal of Research in Education and Science
6	Surya and Syahputra (2017). Development of a PBL learning approach.	Higher-order thinking	2017	International Education Studies
7	Hendriana et al. (2018). PBL in senior high school mathematics.	Mathematical problem solving; self-confidence	2018	Journal on Mathematics Education
8	Napitupulu et al. (2016). PBL in upper secondary mathematics.	Mathematical reasoning; higher-order thinking as classified in the inventory	2016	Journal on Mathematics Education
9	Maulidiya and Nurlaelah (2019). PBL in mathematics education.	Critical thinking	2019	Journal of Physics: Conference Series [proceedings]
10	Nasution et al. (2018). PBL in mathematics.	Mathematical problem solving	2018	IOP Conference Series: Materials Science and Engineering [proceedings]
11	Amin et al. (2021). Mobile blended PBL.	Mathematical problem solving	2021	International Journal of Interactive Mobile Technologies

Note. Outcome domains indicate what was examined and do not by themselves imply statistically significant improvement. The table includes journal articles and conference proceedings as part of the descriptive evidence map.

Higher education

The four higher education entries addressed critical thinking, curiosity, achievement, and problem solving in mathematics-related contexts. Number theory instruction with a cognitive conflict strategy and the use of mathematical problem posing were among the named configurations (Darhim et al., 2020; Zetriuslita et al., 2017). Zetriuslita et al. (2017) reported no significant between-group difference in mathematical curiosity despite a difference in critical thinking. Rattanatumma and Puncreobutr (2016) compared PBL with STAD as separate approaches and reported an advantage for STAD. Aini et al. (2019) examined mathematical critical thinking among university students. Alt et al. (2023), which appeared in the original inventory, was excluded from the mathematics-focused synthesis because the reported intervention was not mathematics-specific.

Table 4. Reported PBL study inventory in higher education

No.	Study and instructional configuration	Outcome domain examined	Year	Publication venue
1	Zetriuslita et al. (2017). PBL with a cognitive conflict strategy in number theory.	Mathematical critical thinking; mathematical curiosity (no significant between-group difference in curiosity)	2017	International Education Studies
2	Aini et al. (2019). PBL for mathematical critical thinking among university students.	Critical thinking	2019	Journal of Physics: Conference Series [proceedings]
3	Rattanatumma and Puncreobutr (2016). PBL compared with STAD at St. Theresa International College, Thailand.	Achievement; problem solving (comparison favored STAD)	2016	Journal of Education and Practice
4	Darhim et al. (2020). PBL and mathematical problem posing in undergraduate mathematics education.	Critical thinking	2020	International Journal of Instruction

Note. Outcome domains indicate what was examined and do not by themselves imply statistically significant improvement. Comparator results are reported where they materially affect interpretation.

Discussion

The analytical set suggests that PBL in mathematics education is represented by a family of instructional configurations rather than a uniform classroom treatment. Interpreting an outcome therefore requires attention to what learners were asked to do, what mathematical content was involved, and what support accompanied the problem task. The relational perspective described by Schettino (2016) provides a conceptual basis for considering mathematical activity together with classroom interaction. The material-development studies of Peranginangin et al. (2019) and Siagian et al. (2019), and the flipped configuration of Ramadhani, Umam, et al. (2019), illustrate distinct ways of organizing that activity. Their differences support explicit reporting of design components but do not identify which individual component caused an observed change. For practice, the central implication is to align the instructional arrangement with a clearly defined mathematical competency and to report the configuration in sufficient detail for readers to interpret that alignment.

Elementary studies place achievement, literacy, problem solving, and critical thinking among the prominent outcome domains in the mapped literature. Their relevance lies in opportunities for learners to connect problem situations with mathematical representations and solution procedures. Within a problem-centered orientation, such connections provide a plausible reason for examining these outcomes, but the present review does not establish a causal mechanism. Fery et al. (2017), Kaharuddin (2018), Mulyanto et al. (2018), and Ahdhianto et al. (2020) address related but distinct mathematical outcomes. The qualitative focus of Al Said et al. (2019) further illustrates why implementation perceptions should be distinguished from direct measurements of student learning. The absence of a named additional strategy in an article should therefore be interpreted as a reporting characteristic rather than proof that an unsupported form of PBL was used.

Junior high school studies connect problem solving with communication, metacognition, self-regulated learning, resilience, and other cognitive or affective domains. These domains are conceptually related because mathematical problem solving can require learners to explain representations, monitor strategies, and judge whether a solution is adequate. Their occurrence, however, depends on the tasks, classroom expectations, and supports built into the lesson. Studies of communication and self-regulation, PBL-oriented materials, and problem solving address different parts of this relationship (Amalia et al., 2017; Siagian et al., 2019; Simamora et al., 2017; Surya et al., 2018). The resilience comparison reported by Hafiz et al. (2017) adds a different affective domain and should not be conflated with retention or treated as an integrated guided-discovery intervention. Teachers and researchers should therefore select assessments that correspond directly to the intended competency rather than assume that one problem-solving activity measures every cognitive and affective outcome.

Culture-related and technology-related entries represent different forms of instructional adaptation. A cultural context changes how a problem is situated, whereas a digital platform changes some of the resources, timing, or conditions through which learners encounter and discuss it. Both can be considered in relation to the learner, the mathematical problem, and the learning environment, but they should not be assumed to operate through the same process. Peranginangin et al. (2019), Wardono et al. (2016), Ramadhani, Umam, et al. (2019), and Amin et al. (2021) therefore illustrate distinct configurations rather than a common added effect. The available synthesis cannot isolate the contribution of PBL from cultural framing, realistic mathematics, flipped sequencing, or digital support. Future studies should specify the role of each component and align it with the mathematical task and assessment rather than attribute outcomes to technology or contextualization alone.

Senior high school studies broaden the mapped outcomes to reasoning, higher-order thinking, statistical thinking, self-confidence, and retention, but this does not demonstrate a developmental progression in PBL effectiveness. Reasoning and critical thinking concern how learners justify or evaluate mathematical work, whereas retention concerns the persistence of learning; these targets require different interpretations. Studies by Napitupulu et al. (2016), Surya and Syahputra (2017), Ajai and Imoko (2015), and Arifin et al. (2020) illustrate this diversity, while Hendriana et al. (2018) also considers self-confidence. The presence of an outcome in senior high school research does not establish its absence or developmental inaccessibility at earlier levels. Cross-level claims would require comparable measures, instructional conditions, and study designs, which are not available in the present evidence map. The appropriate interpretation is therefore that the literature emphasizes different outcomes at different levels, not that PBL follows a proven developmental sequence.

Higher education evidence also cautions against a uniformly positive account of PBL. Zetriuslita et al. (2017) reported different patterns for critical thinking and mathematical curiosity, indicating that cognitive and affective outcomes should not be assumed to respond identically to the same instructional arrangement. Rattanatumma and Puncreobutr (2016) provide a further counterpoint because their comparison favored STAD, whereas Darhim et al. (2020) examined critical thinking in relation to PBL and mathematical problem posing. Aini et al. (2019) adds a university-level account of mathematical critical thinking using a different research design. Together, these studies show why the outcome, comparator, and design must all be specified before interpreting a result. The evidence supports conditional instructional choices rather than a universal recommendation that PBL should replace other approaches.

The review contributes a descriptive connection among educational level, instructional configuration, and outcome domain. This emphasis differs from the problem-solving focus of Suparman et al. (2021) without claiming that the present review is the first to address design variation. Comparisons with realistic mathematics education and other learning approaches likewise show that the comparator is part of the interpretation of a design (Susanti & Rustam, 2018; Tanjung et al., 2020). The review does not test a new theory, estimate a pooled effect, or demonstrate that the descriptive mapping itself improves learning. Its value lies in making design features and assessed domains explicit so that future interventions can state more precisely which component is intended to support which mathematical or affective outcome. This distinction also helps prevent the use of a PBL label as a substitute for a sufficiently detailed description of instruction.

For instructional design, the mapped literature suggests that at least four decisions should be made explicit when PBL is planned or reported. First, the mathematical problem should be linked to the intended competency so that a task designed for problem solving is not assumed to assess communication, self-regulation, or critical thinking automatically. Second, additional components such as cultural contexts, GeoGebra, learning-management systems, flipped sequencing, or realistic mathematics approaches should be described as distinct design features rather than absorbed into the PBL label. Third, the role of the comparator should be stated clearly, especially when another active approach is used. The findings of Rattanatumma and Puncreobutr (2016), Hafiz et al. (2017), and Arifin et al. (2020) show why the interpretation of an outcome depends on what PBL was compared with and which resources were assigned to each condition. Fourth, assessment should correspond to the intended outcome domain. These reporting decisions do not prescribe a single preferred PBL model; instead, they make the instructional logic visible enough for readers and practitioners to judge whether the task, support, comparison, and assessment are coherently aligned.

The evidence map also identifies priorities for future primary studies and future reviews. Primary studies would be easier to compare if they reported the mathematical topic, problem structure, grouping arrangement, teacher support, duration, digital or cultural components, comparator condition, and outcome measure with sufficient detail to distinguish one configuration from another. When several components are introduced simultaneously, authors should avoid attributing any observed difference to PBL alone unless the research design supports that inference. Future evidence syntheses should likewise preserve complete database-specific search strings, search dates, deduplication records, screening decisions, extraction procedures, and formal appraisal results. Those records would allow later reviewers to determine whether apparently different conclusions arise from different evidence sets, eligibility rules, or methodological-quality thresholds. The present review cannot reconstruct those missing elements retrospectively, but making the limitation explicit helps separate what is known from what remains uncertain. This distinction is also important for cumulative research: a transparent evidence trail enables future syntheses to update the literature without treating earlier descriptive inventories as if they were fully reproducible systematic reviews.

Limitations

Several limitations remain because the available review record is incomplete. Exact database search strings, the final search date, source-specific retrieval counts, the original exclusion log, duplicate-extraction procedures, and a formal methodological-quality appraisal were not available and were not reconstructed. The evidence map also includes heterogeneous research designs and publication types, so the presence of a study in a table should not be interpreted as equal evidential weight. The source-level scope audit removed four entries whose mathematics relevance could not be established confidently. These limitations reduce reproducibility and preclude strong comparative claims about effectiveness. The results should therefore be used to identify instructional configurations and outcome domains that warrant more rigorously documented future review and primary research.

CONCLUSION

This review mapped 35 mathematics-focused studies from a reported 2015–2023 literature inventory across elementary, junior high school, senior high school, and higher education settings. The studies represented PBL without a named additional approach as well as culture-related, strategy-linked, material-development, and technology-supported configurations, with outcomes spanning mathematical performance and affective domains. The literature does not support a claim of uniform benefit or the superiority of one PBL configuration: comparator advantages, nonsignificant findings, and heterogeneous study designs require a conditional interpretation. The main contribution is therefore a descriptive map linking instructional configuration, educational level, and assessed outcome. Stronger recommendations will require a future review with fully reproducible search documentation, explicit screening records, and formal study-quality appraisal.

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AUTHOR CONTRIBUTION STATEMENT

H. Responsible for formulating the study topic and focus, developing research questions, defining the literature review objectives, designing the literature search strategy, coordinating the article identification and selection process, leading the analysis and synthesis of findings, structuring the article, writing the main body of the manuscript, integrating input from all members, revising the manuscript, and ensuring consistency in methodology, content, and quality prior to publication. **K**. Assists in identifying and gathering relevant scholarly articles based on inclusion and exclusion criteria, conducting searches across databases and academic sources, supporting the literature screening and selection process, extracting data from selected articles, and contributing to the analysis and interpretation of the study findings.

AI DISCLOSURE STATEMENT

The authors used ChatGPT (OpenAI) during the preparation of this work to support language editing, manuscript organization, and reference checking. After using the tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

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