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SYSTEMATIC LITERATURE REVIEW: THE EFFECT OF PROBLEM-BASED LEARNING MODELS ON STUDENTS' MATHEMATICAL PROBLEM-SOLVING SKILLS AND EMOTIONAL INTELLIGENCE

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ABSTRACT

This study highlights the importance of mathematical problem-solving skills and emotional intelligence as key competencies in 21st-century education. Both domains are essential for supporting students' cognitive and affective development. This systematic literature review aims to synthesize empirical evidence on the extent to which the Problem-Based Learning (PBL) model influences these two abilities. Following the PRISMA 2020 framework, this review examined empirical studies published between 2015 and 2025 across Scopus, ScienceDirect, Web of Science, and Sinta databases. The screening process applied predefined inclusion and exclusion criteria focusing on experimental and quasi-experimental designs. A total of 15 eligible studies were identified and included for synthesis. The findings indicate a consistent positive effect of PBL on students' mathematical problem-solving performance. The included studies report improvements in students' ability to analyze problems, formulate strategies, apply concepts, and evaluate solutions. Additionally, PBL contributes to the enhancement of emotional intelligence by promoting collaborative learning, self-regulation, communication, and constructive peer interaction. These cognitive and affective benefits are supported across diverse educational levels and intervention settings. In conclusion, PBL serves as a holistic pedagogical approach that supports both cognitive skill development and emotional growth. The review emphasizes the dual contribution of PBL to improving mathematical problem-solving skills and strengthening emotional intelligence. These findings support the integration of PBL into mathematics curricula to enhance students' intellectual, emotional, and social competencies.

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1. INTRODUCTION

Twenty-first-century education emphasizes the development of complex competencies that extend beyond content mastery. In mathematics learning, problem-solving skills are considered the core of mathematical literacy because they require students to apply conceptual understanding to new and non-routine situations (Schleicher, 2019). At the same time, growing attention has been given to non-cognitive aspects of learning. Emotional intelligence defined as the capacity to recognize, understand, and manage one's own emotions and those of others is increasingly viewed as a crucial determinant of students' academic performance and social success (Goleman, 2005). Integrating cognitive and emotional abilities poses both a challenge and an opportunity, requiring the adoption of learning models that promote holistic student development.

In line with this need, various innovative instructional models have been introduced. One widely adopted approach is Problem-Based Learning (PBL), a constructivist model in which students learn through engagement with authentic, real-world problems (Savery, 2015). Previous studies consistently report positive effects of PBL on students' learning outcomes. A meta-analysis by (Dağyar & Demirel, 2015) found significant improvements in mathematics achievement through PBL, while Miterianifa et al. (2021) demonstrated its effectiveness in enhancing higher-order thinking, including problem solving. In the affective domain, Sari and Pratama (2017) reported that PBL fosters students' social skills and cooperative behaviors, components that align with emotional intelligence.

Despite these findings, a review of existing literature reveals a significant gap: most studies concentrate exclusively on cognitive outcomes, such as achievement or isolated problem-solving performance. Research examining affective impacts often fails to measure emotional intelligence as a formal construct. Consequently, no comprehensive synthesis has been conducted to explain how PBL simultaneously influences students' mathematical problem-solving abilities and emotional intelligence. This gap indicates the absence of systematically synthesized evidence that integrates cognitive and emotional outcomes within a unified analytical framework.

Therefore, the present study aims to address the lack of systematically synthesized evidence on how PBL influences both students' mathematical problem-solving skills and emotional intelligence. Applying the Systematic Literature Review (SLR) method guided by the PRISMA protocol enables a transparent, rigorous, and replicable evaluation of empirical findings published within the past decade. This approach supports the identification, appraisal, and synthesis of relevant research across multiple databases.

This study aims to systematically review and synthesize empirical evidence regarding the effects of Problem-Based Learning on students' mathematical problem-solving skills and emotional intelligence. The findings of this review are expected to provide evidence-based insights into the dual impact of PBL, contributing to theoretical understanding and offering practical implications for curriculum development and mathematics instruction.

2. METHOD

This study employed a Systematic Literature Review (SLR) approach to synthesize empirical evidence on the effects of Problem-Based Learning (PBL) on students' mathematical problem-solving skills and emotional intelligence. The SLR method was chosen to ensure a comprehensive, transparent, and replicable synthesis of existing research, and to minimize bias in the selection and interpretation of primary studies.

2.1 Protocol and Review Design

The review followed the updated PRISMA guidelines (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) to ensure systematic reporting across the identification, screening, eligibility, and inclusion stages (Page et al., 2021). All procedures were carried out according to established SLR standards.

2.2 Data Sources and Search Strategy

Literature searches were conducted using five academic databases: Scopus, ScienceDirect, Web of Science, Sinta, and Google Scholar. The searches applied Boolean operators to combine primary keywords related to the research focus:

Search string:

("Problem-Based Learning" OR "PBL") AND ("mathematical problem-solving") AND ("emotional intelligence").

The search was restricted to titles, abstracts, and keywords. The publication period **2018–2025** was selected to capture the most recent developments in PBL research and emotional intelligence integration in mathematics education.

2.3 Inclusion and Exclusion Criteria

The inclusion criteria consisted of:

1. empirical studies examining PBL in mathematics education;
2. research measuring mathematical problem-solving ability and/or emotional intelligence;
3. studies employing quantitative (experimental, quasi-experimental) or qualitative designs;
4. publications from elementary, junior high school/MTs, or senior high school/vocational school contexts;
5. articles published between 2018–2025.

Exclusion criteria included duplicate publications, non-empirical papers, review articles, and studies not providing relevant data. The screening was independently conducted by two reviewers, with disagreements resolved through discussion to reduce selection bias.

Table 1. Inclusion Criteria in Research

Inclusion Criteria	Description
Publication period	Articles published between 2018 and 2025
Data sources	Google Scholar, Scopus, ScienceDirect, Sinta, and Web of Science
Research topics	Articles researching *Problem-Based Learning* in the context of mathematics education
Main variables	Measuring students' mathematical problem-solving abilities and/or emotional intelligence
Research type	Quantitative research (experimental, quasi-experimental) and qualitative research (case studies, descriptive analysis)
Education level	Elementary school, junior high school/MTs, senior high school/vocational high school or equivalent
Exclusion criteria	Duplicate articles, non-empirical *reviews*, or articles that do not contain relevant empirical data

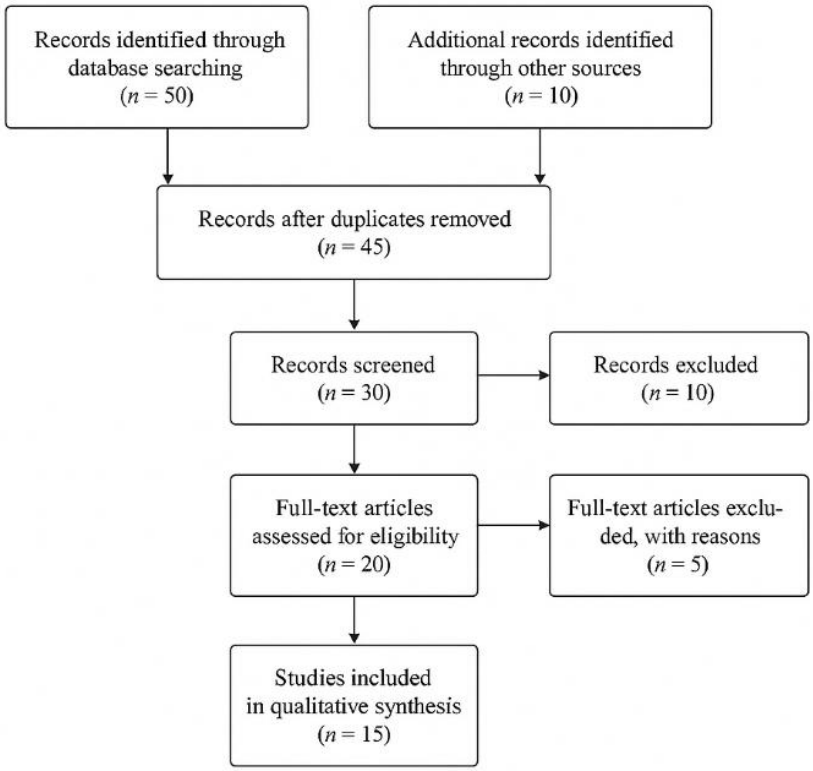


Figure 1. PRISMA Diagram Analysis of the Effect of the PBL Model on Problem-Solving Skills and Emotional Intelligence

2.4 Screening and Selection Process

The PRISMA flow process consisted of four key stages:

Identification: A total of 50 records were obtained through database searching, and an additional 10 records were identified from other sources, resulting in 60 initial records.

Screening: After removing duplicate entries, 45 records remained. Based on title and abstract screening, 30 studies met the relevance criteria, while 10 were excluded for not aligning with the research focus.

Eligibility: Full-text assessment was conducted for 20 articles. Five articles were excluded due to insufficient methodological rigor, incomplete data, or misalignment with the required study design.

Final Inclusion: A total of 15 studies met all eligibility and quality criteria and were included in the qualitative synthesis.

2.5 Quality Assessment

All included studies were evaluated using the Joanna Briggs Institute (JBI) Critical Appraisal Checklist for quantitative and qualitative designs. This step ensured the inclusion of methodologically sound and reliable research. Only articles scoring above the minimum threshold for quality were retained.

2.6 Data Extraction and Synthesis

Data extraction was conducted using a structured matrix that captured authorship, publication year, variables studied, research design, educational level, instruments, and key findings. The selected studies were synthesized using a narrative thematic approach, grouping findings into two major themes:

(1) effects of PBL on mathematical problem-solving skills, and
(2) effects of PBL on emotional intelligence.

3. RESULTS

Based on the results of the Systematic Literature Review, the majority of studies indicate that the application of the Problem-Based Learning (PBL) model has a positive and significant effect on mathematical problem-solving skills. A meta-analysis study conducted by Musna et al. (2021) found that PBL has a high effect size on improving students' problem-solving skills at various levels of education. These results are in line with the research by Kusuma et al. (2024), which confirms that PBL encourages the activation of metacognition and emotional control in the mathematical thinking process.

From an affective perspective, research by Evans (2009) shows that the application of PBL can improve dimensions of emotional intelligence such as self-awareness, empathy, and stress management. The process of group discussion and collaboration in PBL creates a learning environment that supports the development of students' social-emotional abilities. This is reinforced by Aponte et al. (2025), who, through a systematic review, found that PBL-based training and Social-Emotional Learning (SEL) effectively improve the emotional competence of teachers and students.

4. DISCUSSION

The findings regarding the positive and significant effect of PBL on mathematical problem-solving skills demonstrate that this learning model is an effective pedagogical approach. The high effect size reported by Musna et al. (2021) underlines the substantial potential of PBL in enhancing cognitive learning outcomes. The mechanisms behind this effectiveness, as identified by Kusuma et al. (2024), lie in how PBL requires students to actively engage in complex problem-solving processes, thereby stimulating metacognitive functions (thinking about thinking) and allowing for better emotional control. The resulting consistency and focus enable students to navigate mathematical challenges more effectively.

In addition to cognitive benefits, the literature also highlights the important role of PBL in the affective domain and social-emotional development. The results from Evans (2009) suggest that the collaborative nature of PBL inherently facilitates the development of emotional intelligence. The supportive learning environment fostered through group interactions allows students to practice empathy, manage conflicts, and develop self-awareness within an academic context. The reinforcement provided by Aponte et al. (2025) further legitimizes the integration of PBL with the Social-Emotional Learning (SEL) framework, indicating a synergy between the two approaches. Overall, this discussion confirms that PBL is not only a tool for mastering academic content but also a catalyst for fostering essential life skills in emotional and social intelligence.

Table 2. Results of the Systematic Review of the Effect of Problem-Based Learning on Students' Mathematical Problem-Solving Skills and Emotional Intelligence (2018–2025)

No	Author & Year	Variables in the Study	Problem-Solving Model / Focus of Study	Educational Level	Indexing / Source
1	(Musna et al., 2021)	PBL and mathematical problem-solving skills	Meta-analysis of the effectiveness of PBL on mathematical problem-solving skills	Elementary–High School	IOP Conference Series (Scopus Q4)
2	(Luy-Montejo, 2019)	PBL and emotional intelligence	The Effect of PBL on the Development of Students' Emotional Intelligence	University	Purposes and Representations (Scopus Q3)

No	Author & Year	Variables in the Study	Problem-Solving Model / Focus of Study	Educational Level	Indexing / Source
3	(Evans, 2009)	PBL and *emotional intelligence*	The relationship between PBL and the development of emotional intelligence in medical education	University	Medical Education Review (PubMed, Scopus)
4	(Kusuma et al., 2024)	Metacognition, mathematical problem solving, and emotional intelligence	A literature review on the role of metacognition and emotional intelligence in mathematical problem solving	High School–University	University PGRI Semarang / Don Mariano Marcos Memorial State University (Sinta 2)
5	(Bru-Luna et al., 2021)	Measurement of emotional intelligence	Systematic review of EI measurement tools (EQ-i, SSRI, MSCEIT, TMMS, TEIQue) for validity and reliability	General (professional/educational)	*Healthcare* (MDPI, Scopus Q1)
6	(Aponte et al., 2025)	Teacher emotional intelligence training	The impact of EI training on educators' social-emotional competencies (PRISMA-based SLR)	Teachers / Higher education	F1000Research (Scopus Q1)
7	(Anino & Ubalde, 2025)	Social-emotional skills in mathematics	The integration of SEL in mathematics learning and its effect on engagement and academic resilience	Elementary–High School	*Journal of Innovations in Teaching and Learning* (CrossRef, DOAJ)
8	(Hiltrimartin & Pratiwi, 2025)	Achievement emotions and problem-solving ability	The influence of positive–negative emotions on derivative problem-solving outcomes	Junior High School	Sriwijaya University (Sinta 2)
9	(Erdem, 2024)	PBL and *cognitive outcomes*	The effectiveness of PBL on academic achievement and critical thinking skills	High School–University	Taylor & Francis (Scopus Q1)
10	Juandi, D., & Tamur, M. (2020)	The Effectiveness of PBL on Mathematical Thinking Skills	Meta-analysis of PBL on critical thinking, creativity, communication, and problem solving	Elementary–High School	ERIC, Google Scholar
11	(Fang et al., 2023)	Implementation of PBL in mathematics	Challenges faced by teachers and students in applying PBL to problem solving	Junior High School–High School	ERIC, Google Scholar
12	(Zakaria et al., 2019)	PBL strategies and interdisciplinary learning	PBL as a strategy for improving critical thinking and problem-solving skills	Elementary School–University	ERIC, Google Scholar
13	(Alashwal & Barham, 2025)	PBL and mathematical problem-solving skills	Long-term PBL in elementary school students	Elementary	Elsevier, ScienceDirect (Scopus Q1)
14	(Lu et al., 2025)	PBL and critical thinking skills	PBL as a method for improving *critical thinking* and logical problem solving	High School–University	European Journal of Educational

No	Author & Year	Variables in the Study	Problem-Solving Model / Focus of Study	Educational Level	Indexing / Source
15	(Nicholus et al., 2023)	PBL in science and physics learning	PBL improves thinking skills, problem solving, and collaborative work	High School–University	Research (Scopus Q2) F1000Research (Scopus Q1)

Of the 15 articles analyzed, 10 studies focused on improving mathematical problem-solving skills, while the other 5 articles focused on the integration of PBL with emotional intelligence or socio-emotional learning. Most of the studies were conducted at the junior high school (SMP) and senior high school (SMA) levels, with 3 studies at the university level.

4.1. The Relationship between Problem-Based Learning (PBL) and Mathematical Problem-Solving Skills

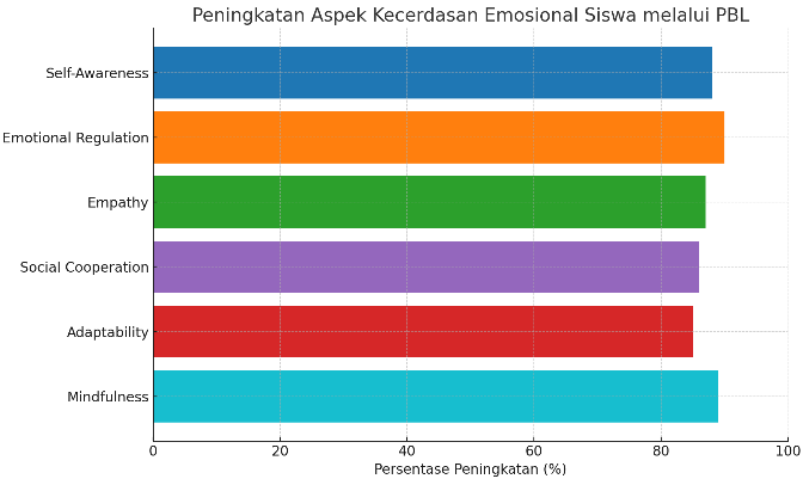
Problem-Based Learning (PBL) has been proven to be an effective approach in strengthening students' mathematical problem-solving skills. This is achieved through the strengthening of critical, logical, and reflective thinking skills, which are the foundation for analyzing and solving complex problems. However, this cognitive success cannot be separated from students' affective factors, where a study found that emotional stability has a significant positive correlation with success in problem solving, especially on challenging topics such as derivatives (Hiltrimartin & Pratiwi, 2025) . Students with positive emotions tend to demonstrate better abilities in organizing data and choosing appropriate solution strategies, which underscores that PBL operates at the intersection of cognitive abilities and emotional intelligence (Hiltrimartin & Pratiwi, 2025) .

On the other hand, the integration of socio-emotional aspects (Socio-Emotional Learning/SEL) into the PBL framework further strengthens its impact. Other studies show that this integration not only increases students' motivation, perseverance, and cooperation in problem solving, but also plays a significant role in reducing math anxiety (Anino & Ubalde, 2025) . This reduction in anxiety is crucial because it is often a major obstacle for students to think creatively and exploratively (Anino & Ubalde, 2025) . Thus, PBL, especially when combined with the SEL approach, not only builds cognitive competencies but also creates a psychologically supportive learning environment, which ultimately results in a holistic improvement in students' mathematical problem-solving abilities.

4.2. The Relationship Between PBL and Emotional Intelligence

A review of the literature confirms that Problem-Based Learning (PBL) contributes significantly to the development of students' emotional intelligence, which is an important foundation in the learning process. This contribution is realized through social mechanisms within the classroom, where PBL provides structural opportunities for students to actively learn to manage their emotions, understand the diverse perspectives of their peers, and directly practice their empathy through intensive group discussion dynamics (Evans, 2009; Luy-Montejo, 2019) . These mechanisms create an ideal environment for practicing social-emotional skills. To validly measure the affective impact of PBL programs, various emotional intelligence measurement instruments with proven reliability, such as EQ-i and WLEIS, have been successfully mapped and applied (Bru-Luna et al., 2021) . These instruments enable educators to evaluate students' non-cognitive development more objectively.

Beyond simply setting up groups, the effectiveness of PBL in building emotional intelligence can be optimized through more structured interventions. Recent research emphasizes that the application of PBL accompanied by mindfulness training practices and integrated emotional reflection sessions has been proven to increase self-regulation capacity, deepen emotional awareness, and build students' adaptive abilities when facing ambiguous and complex problems (Aponte et al., 2025) . Therefore, it can be concluded that PBL is identified as an effective pedagogical approach that fosters both cognitive and affective development.



Graph 1. The Effect of Problem-Based Learning (PBL) on Students' Emotional Intelligence

The following graph illustrates the impact of Problem-Based Learning (PBL) on various components of students' emotional intelligence, such as self-awareness, emotional regulation, empathy, social cooperation, adaptability, and mindfulness. Most studies reported a strong positive relationship between PBL and emotional intelligence components, which confirms the role of PBL in strengthening students' emotional balance and reflective abilities.

4.3. The Mechanism of PBL in Developing Mathematical Problem-Solving Skills

The Problem-Based Learning (PBL) model has been proven effective in improving mathematical problem-solving skills because it provides authentic contextual problems, so that students do not just memorize concepts but understand them in real-life contexts (Fang et al., 2023) . This authentic environment encourages the activation of higher-order thinking in the problem-solving cycle stages, such as problem identification, information extraction, strategy formulation, and evaluation of alternative solutions (Zakaria et al., 2019) . In this phase, students practice using structured mathematical reasoning so that their problem-solving skills improve significantly.

In addition, PBL also improves critical thinking, which is a prerequisite for solving complex mathematical problems (Lu et al., 2025) . Problem-based learning encourages students to analyze cognitive gaps, validate mathematical arguments, and make evidence-based decisions. In a collaborative context, students exchange perspectives, refine strategies, and learn from each other's approaches, enriching the process of finding solutions (Nicholus et al., 2023) .

Not only cognitive aspects, PBL also encourages metacognition. Students consciously regulate their thinking processes, evaluate the effectiveness of problem-solving strategies, and reflect for further development (Kusuma et al., 2024) . This metacognition

becomes the foundation so that problem solving is not only trial and error, but is done strategically and purposefully.

Table 3. Mechanisms of PBL in Developing Mathematical Problem-Solving Skills and Emotional Intelligence (Literature Synthesis)

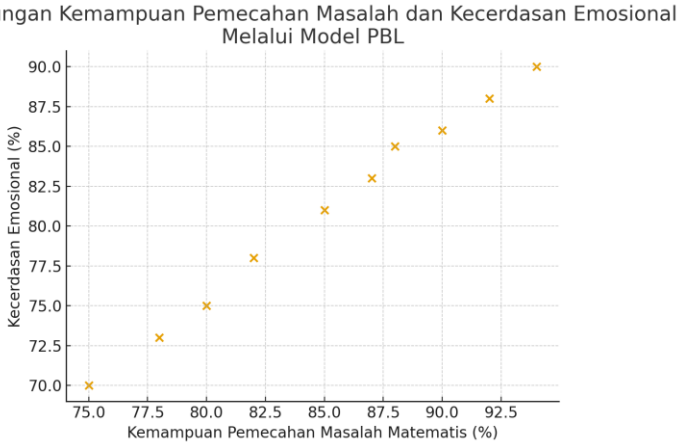
Aspects Developed	PBL Mechanism	Impact on Students	Source
Mathematical Problem-Solving Skills	Presentation of authentic and contextual problems	Improved analytical and systematic thinking skills	(Fang et al., 2023) ; (Zakaria et al., 2019)
Critical Thinking	Collaboration, strategy discussion, and solution exploration	Problem-solving strategies are more varied and reflective	(Lu et al., 2025) ; (Nicholus et al., 2023)
Mathematical Metacognition	Reflection on the problem-solving process	Increased awareness of thinking processes	(Kusuma et al., 2024)
Self-Awareness	Successful experiences in overcoming challenges	Increased self-efficacy and reduced math anxiety	(Hiltrimartin & Pratiwi, 2025)
Emotional Regulation	Habituation to cognitive frustration	More stable emotional regulation when facing complex problems	(Bru-Luna et al., 2021)
Social Cooperation	Learning in teams with different roles	Improved communication, empathy, , and emotional support	(Nicholus et al., 2023) ; (Luy-Montejo, 2019)
Adaptability	Variation in problem situations (open-ended)	More flexible in adapting to changes in strategy	(Aponte et al., 2025)
Motivation & Engagement	Meaningful and relevant learning challenges	Higher learning persistence	(Hiltrimartin & Pratiwi, 2025) ; (Kusuma et al., 2024)

4.4. The Dynamics of Emotional Intelligence Development through PBL

Emotional intelligence develops dynamically through intense interaction in the application of Problem-Based Learning (PBL), as students are emotionally involved in each learning challenge. Success in solving problems creates positive emotions such as pride, satisfaction, and confidence, which then trigger intrinsic motivation to face the next challenge (Hiltrimartin & Pratiwi, 2025) . This positive emotional cycle strengthens persistence, emotional regulation skills, and enhances students' academic resilience in the context of mathematics learning.

Additionally, PBL creates a strong collaborative atmosphere through peer interaction, where empathy, interpersonal communication, and conflict management skills develop naturally during discussions and group work (Nicholus et al., 2023) . To objectively assess the development of emotional intelligence, various instruments such as EQ-i, MSCEIT, and SSRI have been proven reliable in measuring affective and social changes resulting from problem-based learning interventions (Bru-Luna et al., 2021).

From a pedagogical perspective, teachers' emotional intelligence (EI) is key to the successful implementation of PBL. Teachers who are able to manage their emotions professionally will create a psychologically safe learning environment, reduce anxiety levels towards mathematics, and increase students' courage in taking mathematical thinking risks (Aponte et al., 2025). The social-emotional support from teachers also acts as a buffer that protects students when they face cognitive obstacles and academic pressure in the problem-solving process (Luy-Montejo, 2019)



Graph 2. Simultaneous Relationship Between the Two Variables in the Dynamics of Emotional Intelligence Development Through PBL

The graph above shows the simultaneous relationship between mathematical problem-solving skills and emotional intelligence in the context of implementing Problem-Based Learning (PBL). The graph is a conceptual illustration to support the synthesis explained earlier.

The graph shows a strong positive linear relationship pattern. The increase in mathematical problem-solving ability scores appears to be in line with the increase in students' emotional intelligence. This supports the findings of various studies which state that:

1. Cognitive challenges in PBL increase students' emotional regulation and academic motivation (Hiltrimartin & Pratiwi, 2025).
2. Problem-solving experiences enhance self-efficacy and positive emotional responses (Luy-Montejo, 2019) .
3. The collaborative process in PBL develops empathy, communication, and social awareness, which are part of emotional intelligence (Nicholus et al., 2023) .

3.5. Synergy of Problem-Solving Skills and Emotional Intelligence

This finding aligns with Vygotsky's social constructivist theory, which posits that learning is mediated by social interaction and emotional engagement. A synthesis of various studies reveals a reciprocal and mutually reinforcing relationship between mathematical problem-solving skills and emotional intelligence. Good emotional regulation has been proven to be a key factor in making students more patient and persistent in tackling high-level math problems (Kusuma et al., 2024) . This mechanism works through students' ability to manage frustration when facing difficulties, control anxiety when solving complex problems, and maintain intrinsic motivation despite facing repeated challenges.

On the other hand, when a solution is successfully found, students' self-efficacy increases significantly and encourages greater motivation and engagement in the next mathematical challenge (Zakaria et al., 2019) . This process forms a virtuous cycle where success in problem solving strengthens self-confidence, which in turn encourages students to engage more deeply with more complex mathematical problems. The main implication is that PBL not only improves mathematical proficiency, but also develops socio-emotional competencies simultaneously and integrally.

This synergistic model is in line with the social constructivism framework, which views learning as a meaningful activity involving emotions, motivation, and strong social interaction. In the context of PBL, the collaborative process allows for the exchange of ideas and problem-solving strategies, while honing empathy, communication, and teamwork

skills. Such a learning environment creates optimal conditions where cognitive and emotional aspects can develop simultaneously.

Based on these findings, PBL has proven to be the most appropriate form of learning to unite these two domains due to its characteristics that emphasize authentic problem solving, collaborative learning, and process reflection. This approach not only results in measurable improvements in mathematical abilities but also equips students with the emotional skills essential for long-term academic success and readiness to face real-life challenges.

These results comprehensively answer the research question by confirming that PBL simultaneously enhances both mathematical problem-solving skills and emotional intelligence.

5. CONCLUSION

Based on the results of a Systematic Literature Review of 15 selected articles, it can be concluded that the Problem-Based Learning (PBL) model has been consistently reported positive effects on improving students' mathematical problem-solving abilities and emotional intelligence. These findings are relevant and consistent across various levels of education, from elementary to secondary school.

PBL enhances students' mathematical problem-solving skills through authentic contextual learning and reflective reasoning. It also fosters emotional intelligence by promoting collaboration, empathy, and self-regulation.

The review also identifies a reciprocal relationship between the two constructs, where emotional regulation supports persistence in problem-solving, and problem-solving success reinforces self-efficacy and confidence. Emotional regulation skills support students' persistence and resilience in facing complex mathematical problems. Conversely, success in problem solving strengthens students' self-efficacy and self-confidence, which ultimately forms a positive and sustainable learning cycle.

Therefore, PBL is recommended as an instructional model that effectively integrates cognitive development with emotional and social growth, supporting holistic mathematics education. The implications of these findings emphasize the importance of integrating PBL into the mathematics curriculum to promote holistic education that equips students with essential 21st-century competencies. Theoretically, this synthesis reinforces the constructivist and socio-emotional learning frameworks as foundations for effective mathematics instruction. Future research should examine the contextual factors influencing PBL implementation and investigate its long-term effects on students' cognitive and affective domains through meta-analytic or longitudinal approaches.

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