

Problem-Solving Learning: A Systematic Literature Review of Learning Outcomes and Thinking Skills

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ABSTRACT

Problem-solving learning has been implemented across various educational contexts through different instructional approaches. However, evidence regarding its implementation patterns, instructional characteristics, and reported outcomes remains dispersed across studies. This systematic review aimed to synthesize the implementation of problem-solving learning and its reported learning outcomes and thinking skills across educational contexts. The review followed the PRISMA 2020 guidelines. Articles published between 2020 and 2026 were retrieved from Scopus, ERIC, Google Scholar, and Dimensions. A total of 17 empirical studies met the inclusion criteria and were analyzed using qualitative thematic synthesis. The findings showed that problem-solving learning was implemented through diverse approaches, particularly Creative Problem Solving (CPS) and its variants, collaborative problem-solving, inquiry-based problem solving, and multimedia-assisted problem solving. Recurring instructional characteristics included contextual problems, inquiry activities, collaboration, and the use of instructional supports such as simulations, multimedia, and multiple representations. The reviewed studies reported learning outcomes related to learning achievement, conceptual understanding, scientific work skills, student engagement, learning motivation, and metacognitive development. Problem-solving learning was also associated with critical thinking, creative thinking, problem-solving skills, collaborative problem-solving, and metacognitive skills. Most of the available evidence originated from science-related disciplines, particularly chemistry, biology, physics, and science education.

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1. INTRODUCTION

Deep Learning has emerged as an educational approach that emphasizes meaningful understanding and active knowledge construction (Entwistle, 2000). The approach encourages students to engage deeply with concepts rather than merely memorize information. It also aims to develop higher-order thinking skills through authentic and meaningful learning experiences (Du et al., 2025; Purnomo et al., 2022). Deep Learning positions students as active participants in learning through the principles of mindful,

meaningful, and joyful learning (Andayanie et al., 2025; Ricita et al., 2025). Consequently, learning is directed not only toward content mastery but also toward students' ability to analyze, reason, and solve contextual problems (McGregor, 2020). In the Indonesian context, the government plans to implement the Deep Learning approach at the primary and secondary education levels beginning in the 2025/2026 academic year as part of broader educational reform initiatives. This policy aims to strengthen students' critical thinking, analytical thinking, and problem-solving abilities in response to the demands of twenty-first-century learning (Eritrina & Darwis, 2026; Nurhasanah et al., 2025; Prihantoro et al., 2025).

Various instructional approaches have been used to support the development of students' thinking skills and learning outcomes, including problem-based learning (PBL), project-based learning (PBL), inquiry learning, and problem-solving learning (Tang, 2023; Bara & Xhomara, 2020). Among these approaches, problem-solving learning emphasizes a systematic process of identifying problems, analyzing relevant information, generating alternative solutions, and evaluating outcomes (Anderson, 1993). Such learning processes encourage students to engage actively with knowledge and apply it to meaningful situations. As a result, problem-solving learning aligns closely with the principles of Deep Learning, which emphasize meaningful engagement and the application of knowledge in authentic contexts (Indraganti, 2018). This approach has been implemented through various instructional forms, including Creative Problem Solving (CPS), collaborative problem-solving, experimental-based learning, and multimedia-assisted problem solving (Susilawati et al., 2024). These variations demonstrate the adaptability of problem-solving learning across different educational contexts and learner characteristics.

Problem-solving learning is grounded in several theoretical perspectives that emphasize the active role of learners in constructing understanding. From a constructivist perspective, knowledge develops through interaction with experiences and problem situations rather than through passive reception of information (Zajda, 2021; Hendry et al., 1999). This view is closely related to inquiry-based learning, which encourages students to investigate questions, examine evidence, and develop conceptual understanding through exploration (Senyigit et al., 2021). Such processes require learners to analyze information, formulate strategies, and evaluate possible solutions, which are central elements of problem-solving theory (Jonassen, 2000). Engagement in these cognitive activities is also associated with the development of higher-order thinking skills, particularly analysis, evaluation, and creation (Widana, 2017). Furthermore, effective problem solving involves students' ability to monitor their own learning processes and reflect on the strategies they use (Azevedo, 2009). Learning is further enriched through interaction with others, as collaborative environments provide opportunities for learners to exchange ideas, develop shared understanding, and construct knowledge collectively (Puntambekar, 2006).

Previous studies have shown that problem-solving learning has been implemented in various educational contexts, including blended learning, contextual learning, STEM education, and experimental-based learning. Several studies have also reported its impact on students' learning outcomes and thinking skills, such as critical thinking, creative thinking, problem-solving skills, and metacognitive skills. These findings demonstrate the broad applicability of problem-solving learning and its potential to support students' cognitive development. However, insights from these studies are often reported within specific educational contexts, making it difficult to identify broader patterns of implementation and reported outcomes. Consequently, a broader understanding of how problem-solving learning is implemented and how outcomes are reported across various educational settings remains limited. Therefore, a systematic review is needed to synthesize evidence regarding the implementation of problem-solving learning, its instructional characteristics, and the learning outcomes and thinking skills reported across educational contexts.

This study aims to examine the implementation of problem-solving learning through a systematic literature review. Specifically, the review focuses on forms of implementation, reported learning outcomes, thinking skills, and instructional characteristics identified across different educational contexts.

This study is guided by the following research questions:

1. How is problem-solving learning implemented across various educational contexts?
2. What learning outcomes have been reported in studies of problem-solving learning?

3. What thinking skills are most frequently reported in studies of problem-solving learning?
4. What instructional characteristics are commonly found in the implementation of problem-solving learning?

2. METHODS

2.1 Research Design

This study employed a Systematic Literature Review (SLR) approach to examine the implementation of problem-solving learning and its reported outcomes across educational contexts. The review process followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines to ensure systematic, transparent, and replicable study selection and reporting procedures (Page et al., 2021).

The SLR approach was selected because problem-solving learning has been implemented through various instructional forms, including Creative Problem Solving (CPS), collaborative problem-solving, multimedia-assisted problem solving, and open-ended learning approaches. These variations require a structured synthesis process to identify implementation patterns, instructional characteristics, and research trends across educational contexts. Similar approaches have been widely applied in educational systematic review studies to synthesize recurring instructional themes and research developments (Da Silva et al., 2023).

2.2 Search Strategy

The literature search was conducted systematically using four databases: Scopus, ERIC, Google Scholar, and Dimensions. The search focused on studies published between 2020 and 2026 to capture recent developments in problem-solving learning within educational settings. The search strategy was developed around three key concepts: problem-solving learning, thinking skills, and educational context.

To accommodate variations in terminology across databases, several keyword combinations were employed. Boolean operators ("AND" and "OR") were used to refine the search and improve the relevance of retrieved studies, following recommendations for systematic literature searching (Atkinson & Cipriani, 2018; Grindlay & Karantana, 2018). Table 1 summarizes the search keywords and Boolean strategy used to identify relevant studies across the selected databases.

Table 1. Search Keywords and Boolean Strategy

Category	Search Keywords
Problem-solving learning	("problem-solving learning" OR "creative problem solving" OR "problem-solving model" OR "collaborative problem-solving")
Thinking skills	("critical thinking" OR "creative thinking" OR "higher-order thinking skills" OR HOTS OR "metacognitive skills" OR "problem-solving skills")
Educational context	("education" OR "learning" OR "teaching" OR "classroom" OR "students" OR "science education" OR "chemistry education")
Boolean strategy	("problem-solving learning" OR "creative problem solving" OR "problem-solving model" OR "collaborative problem-solving") AND ("critical thinking" OR "creative thinking" OR "higher-order thinking skills" OR HOTS OR "metacognitive skills" OR "problem-solving skills") AND ("education" OR "learning" OR "teaching" OR "classroom" OR "students" OR "science education" OR "chemistry education")

The ERIC database search used peer-reviewed and journal article filters. Google Scholar searches applied publication year filters and relevance-based sorting. Searches in Scopus and Dimensions were conducted through article title, abstract, and keyword searches.

2.3 Study Selection Process

The study selection process followed the PRISMA 2020 framework and consisted of four stages: identification, screening, eligibility, and inclusion. These stages were conducted systematically to ensure that the selected studies were relevant to the objectives of the review.

2.3.1 Identification

The identification stage involved article searches across Scopus, ERIC, Google Scholar, and Dimensions using predefined keyword combinations. The search process yielded 10,902 articles consisting of 99 articles from Scopus, 274 articles from ERIC, 1,360 articles from Google Scholar, and 9,169 articles from Dimensions. Initial filtering was conducted by limiting publication years to 2020–2026 and document types to journal articles. Duplicate records and studies unrelated to the research focus were also removed. After the initial filtering process, 49 articles remained for the screening stage.

2.3.2 Screening

The screening stage involved title and abstract analysis of the remaining articles based on predefined inclusion and exclusion criteria commonly used in systematic review studies (Meline, 2006; Stern et al., 2014). The criteria used in the screening process are presented in Table 2.

Table 2. Inclusion and exclusion criteria at the screening stage

Criteria	Inclusion	Exclusion
Research focus	Problem-solving learning	Not discussing problem-solving learning
Context	Educational context	Outside educational context
Research type	Empirical research	Review or conceptual paper
Instructional implementation	Clear implementation of problem-solving learning	No instructional implementation
Outcomes	Reporting learning outcomes or thinking skills	Not reporting learning outcomes

The screening process resulted in the exclusion of 21 articles due to several reasons, including the absence of direct problem-solving implementation, non-educational contexts, review-based designs, unclear instructional implementation, and the absence of reported learning outcomes or thinking skills. Following the screening stage, 28 articles met the initial research criteria and proceeded to the eligibility stage.

2.3.3 Eligibility

The eligibility stage involved full-text analysis of the remaining 28 articles to evaluate their alignment with the research objectives. The analysis focused on instructional implementation, research design, and reported learning outcomes or thinking skills, following systematic review evaluation procedures described by Harris et al. (2014).

Eleven articles were excluded because they primarily focused on media development, lacked clear instructional implementation, emphasized student perceptions without instructional analysis, or did not position problem solving as the primary instructional approach. As a result, 17 studies met all research criteria and were included in the final synthesis.

2.3.4 Inclusion

A total of 17 empirical studies met all eligibility criteria and were included in the final synthesis. These studies formed the basis for the analysis of implementation patterns, instructional characteristics, learning outcomes, and thinking skills associated with problem-solving learning. The overall study selection process is presented in Figure 1

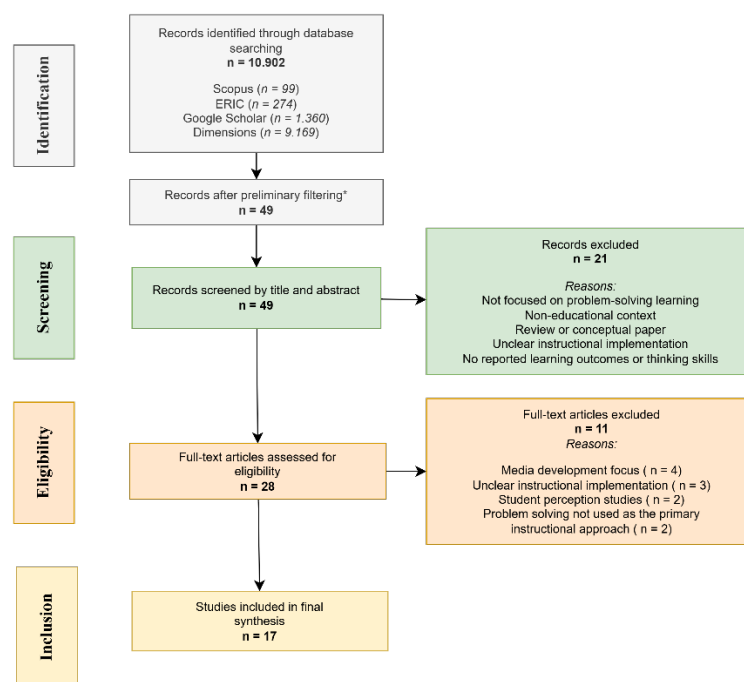


Figure 1. PRISMA 2020 Flow Diagram of Article Selection Process

Note. Preliminary filtering included publication year restrictions (2020–2026), document type selection, duplicate removal, and exclusion of studies not relevant to the objectives of the review.

As shown in Figure 1, the study selection process involved identification, screening, eligibility assessment, and inclusion stages. The studies retained after these stages were subsequently subjected to quality appraisal before data extraction and thematic synthesis.

2.4 Quality Appraisal

Following the eligibility stage, the quality of the included studies was assessed using predefined criteria adapted from previous educational systematic reviews. The assessment considered five aspects: clarity of research objectives, appropriateness of research design, adequacy of sample description, clarity of problem-solving learning implementation, and transparency of outcome reporting. Each study was evaluated against these criteria and retained for synthesis if it met at least three of the five aspects.

The screening and quality appraisal processes were conducted by the author. Although the use of a single reviewer may increase the possibility of selection bias, the same criteria were applied consistently throughout the review process. The criteria applied during the quality appraisal process are summarized in Table 3.

Table 3 presents the quality appraisal criteria used in this study.

Criterion	Description
Research objectives	The study clearly states its research objectives or research questions.
Research design	The research design is appropriate for addressing the study objectives.
Sample description	Participant characteristics and sample size are adequately described.
Implementation clarity	The implementation of problem-solving learning is clearly explained.
Outcome reporting	Learning outcomes or thinking skills are clearly reported.

2.5 Data Extraction

Data extraction was carried out using a structured form to organize information from the included studies. The extracted information included author and publication year, country, education level,

subject area, research design, sample characteristics, problem-solving approach, research instruments, reported learning outcomes, reported thinking skills, instructional characteristics, and key findings. The extracted data were then organized and compared across studies to facilitate thematic synthesis. The results of the data extraction process are presented in Tables 5 and 6.

2.6 Data Analysis

The included studies were analyzed using qualitative thematic synthesis. Information extracted from each study was first subjected to open coding to identify recurring concepts related to publication trends, subject areas, research methods, forms of problem-solving learning, reported learning outcomes, reported thinking skills, and instructional characteristics. Similar codes were then grouped into broader categories, which served as the basis for theme generation.

The coding and categorization processes were conducted by the author. The resulting themes were refined through repeated comparison across studies and continuous reference to the original articles. Throughout the analysis, the categories and themes were repeatedly checked against the extracted data to ensure that the interpretation remained consistent with the reported findings. The final themes formed the basis for the synthesis presented in the Findings and Discussion sections.

3. FINDINGS AND DISCUSSION

3.1 Findings

3.1.1 Study Selection Results

The study selection process yielded 10,902 records from four databases: Scopus, ERIC, Google Scholar, and Dimensions. After preliminary filtering, 49 articles remained for title and abstract screening. Of these, 21 articles were excluded because they did not meet the predefined inclusion criteria. The remaining 28 articles underwent full-text assessment, resulting in the exclusion of 11 articles that did not align with the objectives of the review. Consequently, 17 empirical studies met all eligibility criteria and were included in the final synthesis. The detailed study selection process is presented in Figure 1.

3.1.2 Characteristics of the Included Studies

The 17 studies included in the review were published between 2020 and 2026 and represented a range of educational contexts. Most studies were conducted in science-related fields, particularly chemistry, biology, physics, and science education, while several studies were situated in mathematics, STEAM education, sports education, and engineering education. The studies also employed diverse research designs, with experimental and quasi-experimental methods being the most common. Various forms of problem-solving learning were identified, including Creative Problem Solving (CPS), collaborative problem-solving, multimedia-assisted problem solving, open-ended problem solving, blended problem solving, and self-regulated problem-solving. A summary of the characteristics of the included studies is presented in Table 4.

Table 4. Bibliographic and Contextual Characteristics of Included Studies

No	Author(s)/Year	Country	Education Level	Subject Area
1	Azizah & Nasrudin (2022)	Indonesia	Higher Education	Chemistry
2	Fathonah et al. (2024)	Indonesia	Higher Education	Nutrition Science / Health Science
3	Heliawati et al. (2021)	Indonesia	Vocational High School	Chemistry
4	Yani & Widiyatmoko (2023)	Indonesia	Junior High School	Science
5	Winarti et al. (2022)	Indonesia	Senior High School	Physics
6	Fatmawati et al. (2023)	Indonesia	Senior High School	Biology
7	Fitriani et al. (2025)	Indonesia	Elementary School	Science

No	Author(s)/Year	Country	Education Level	Subject Area
8	Fathonah et al. (2023)	Indonesia	Higher Education	Health Education
9	Aisya et al. (2023)	Indonesia	Senior High School	Biology
10	Winarto et al. (2022)	Indonesia	Higher Education	Science Education
11	Fernández-Cárdenas & Santillán-Rosas (2025)	Mexico	Upper Secondary Education	STEAM Education
12	Karamustafaoglu & Pektas (2023)	Turkey	Senior High School	STEM Education
13	Manurung & Panggabean (2020)	Indonesia	Higher Education	Physics
14	Rahmadi et al. (2024)	Indonesia	Elementary School	Mathematics
15	Aisyah et al. (2026)	Indonesia	Senior High School	Chemistry
16	Thongkorn & Cojorn (2025)	Thailand	Senior High School	Chemistry
17	Zaini et al. (2026)	Malaysia	Higher Education	Chemical Engineering

As shown in Table 4, most of the included studies were conducted in Indonesia and were distributed across various educational levels, ranging from elementary school to higher education. The reviewed studies were predominantly situated in science-related disciplines, particularly chemistry, biology, physics, and science education, although several studies were also conducted in mathematics, STEM/STEAM education, health education, and engineering education. Beyond these contextual characteristics, the studies differed in terms of research design, sample characteristics, problem-solving approaches, instruments, and reported outcomes. These methodological characteristics and key findings are presented in Table 5.

Table 5. Methodological Characteristics and Main Findings of Included Studies

No	Research Design	Sample	Problem-Solving Approach	Instruments	Outcomes	Key Findings
1	Pre-experimental	31 students	Problem-Solving Model	Essay Test	Problem-solving skills	Improved problem-solving thinking skills
2	R&D + Experimental	227 students	MBCPS	Critical Thinking Test, TTCT	Critical & Creative Thinking	Significant improvement in both skills
3	Quasi-experimental	72 students	Open-Ended CPS	Essay Test, Worksheets	Conceptual Understanding, Scientific Work	Improved conceptual understanding and scientific work
4	Quasi-experimental	32 students	PhET-Assisted CPS	Creative Thinking Test	Creative Thinking, Cognitive Outcomes	Significant improvement
5	Quasi-experimental	72 students	SRL-Based Problem Solving	Essay Test, MAI	Metacognition, Learning Outcomes	Improved metacognitive skills
6	Quasi-experimental	66 students	CPS	Essay Test	Creative Thinking, Learning Outcomes	Significant positive effect

No	Research Design	Sample	Problem-Solving Approach	Instruments	Outcomes	Key Findings
7	Pre-experimental	30 students	Problem-Solving Learning	Questionnaire, Test	Motivation, Learning Outcomes	Motivation and achievement increased
8	Quasi-experimental	72 students	MBCPS	Observation, Critical Thinking Test	Critical Thinking	Significant improvement
9	Quasi-experimental	129 students	RQA-CPS	Essay Test	Critical Thinking	Highest critical-thinking performance
10	Mixed Methods	80 students	Ethno-SETSaR PS	Essay Test	Creative Thinking, Problem-Solving Skills	Moderate improvement
11	Mixed Methods	100 students	Dialogic STEAM PS	EITM, Interviews	Critical Thinking, Student Engagement	Improved critical-thinking orientation
12	Mixed Methods	32 students	Inquiry-Based STEM	CPS Scale, Interviews	Creative Problem Solving	Improved CPS and STEM awareness
13	Quasi-experimental	70 students	IMM-PS	TOLT, SPS Test	Thinking Ability	Higher thinking ability than control group
14	Quasi-experimental	40 students	CPS with RME	Essay Test	Mathematical Problem Solving	Significant improvement
15	Pre-experimental	37 students	CPS (OFPIISA)	Essay Test, Observation	Creative Thinking	Moderate N-gain improvement
16	Classroom Action Research	18 students	Collaborative PS	CPS Assessment, Interview	Collaborative Problem Solving	Competency increased across cycles
17	Mixed Methods	Undergraduate students	Open-Ended Laboratories	Questionnaire, Reflection	Problem Solving, Critical Thinking	Improved engineering problem-solving skills

The studies reviewed in this research varied in terms of educational context, research design, problem-solving approaches, and reported outcomes. Examining the distribution of publications over time provides further insight into the development of research on problem-solving learning and helps identify periods of increased scholarly attention to this topic.

3.1.3 Publication Trends

The distribution of publications by year is presented in Figure 2. The reviewed studies were published between 2020 and 2026, indicating continued interest in problem-solving learning across educational settings. An increase in publication frequency was observed between 2022 and 2025, with the highest number of studies published in 2023. This trend suggests growing attention to the use of

problem-solving learning as an approach for developing students' learning outcomes and thinking skills.

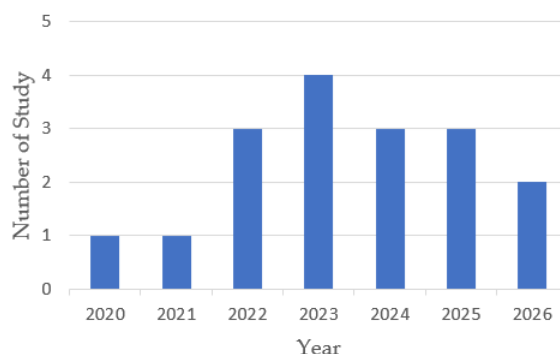
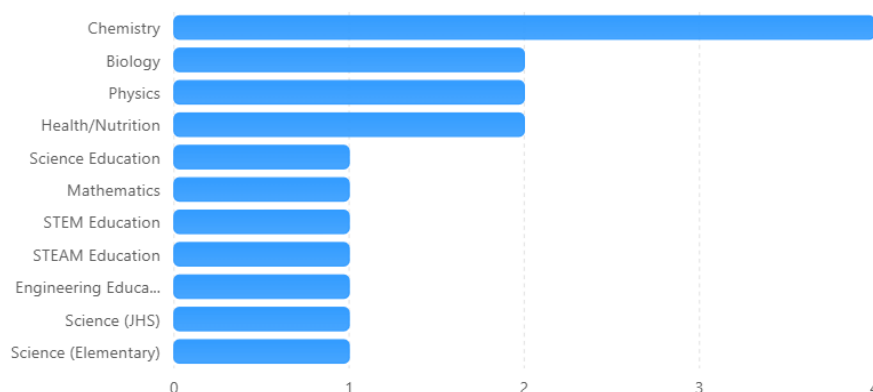


Figure 2. Distribution of publication years of included studies

3.1.4 Subject Areas

The reviewed studies were conducted across a range of subject areas. However, science-related disciplines were the most prominent. Chemistry was the most frequently represented subject area, followed by biology, physics, and health-related education. Other studies were situated in science education, mathematics, STEM education, STEAM education, and engineering education. The distribution of subject areas is presented in Figure 3.



As shown in Figure 3, chemistry accounted for the largest proportion of studies included in the review. Together with biology, physics, science education, and STEM-related fields, these studies indicate that problem-solving learning has been investigated predominantly within science-oriented disciplines. In contrast, relatively few studies were identified in mathematics, engineering, and other educational fields. This pattern suggests that the current evidence base is concentrated in science-related contexts, and therefore, the findings of this review should be interpreted within the disciplinary scope represented by the included studies.

3.1.5 Research Methods

A variety of research designs were identified across the reviewed studies. Quasi-experimental designs were the most frequently used, followed by pre-experimental and mixed-methods approaches. A smaller number of studies employed classroom action research and research-and-development designs.

The predominance of experimental and quasi-experimental designs reflects the emphasis placed on examining outcomes associated with the implementation of problem-solving learning. These studies commonly reported measures related to learning achievement, conceptual understanding, motivation, and thinking skills. Mixed-methods studies complemented quantitative findings with qualitative evidence obtained from observations, interviews, and students' learning experiences, providing

additional information about how problem-solving learning was implemented in different educational contexts.

3.1.6 Types of Problem-Solving Learning

The reviewed studies employed a range of problem-solving learning approaches. Creative Problem Solving (CPS) and its variants were the most frequently reported approaches. Variations of CPS included multirepresentation-based CPS, PhET-assisted CPS, open-ended CPS, and CPS integrated with Realistic Mathematics Education (RME). Other approaches identified in the reviewed studies included collaborative problem-solving, multimedia-assisted problem solving, self-regulated problem solving, inquiry-based problem solving, Ethno-SETSaR problem solving, dialogic STEAM problem solving, and open-ended laboratory problem solving. The approaches identified in the reviewed studies are summarized in Table 6.

Table 6. Types of Problem-Solving Learning Identified in the Reviewed Studies

Problem-Solving Approach	Educational Context
Creative Problem Solving (CPS) and its variants	Chemistry, Biology, Mathematics, Science, Health Education, Nutrition Science
Collaborative Problem-Solving	Chemistry
Multimedia-Assisted Problem Solving	Physics
Self-Regulated Problem Solving	Physics
Inquiry-Based Problem Solving	STEM Education
Ethno-SETSaR Problem Solving	Science Education
Dialogic STEAM Problem Solving	STEAM Education
Open-Ended Laboratory Problem Solving	Chemical Engineering

CPS and its variants were reported across several subject areas, including chemistry, biology, mathematics, science, health education, and nutrition science. Other approaches were implemented in more specific contexts. Multimedia-assisted problem solving and self-regulated problem solving were reported in physics education, inquiry-based problem solving in STEM education, dialogic STEAM problem solving in STEAM education, and open-ended laboratory problem solving in chemical engineering education. Collaborative problem-solving was identified in a chemistry learning context, whereas Ethno-SETSaR problem solving was reported in science education.

Overall, the reviewed studies showed that problem-solving learning has been implemented through a variety of approaches across different educational contexts. However, most approaches were reported in science-related disciplines represented in the reviewed studies.

3.1.7 Reported Learning Outcomes

The reviewed studies reported several learning outcomes associated with problem-solving learning, including learning achievement, conceptual understanding, scientific work skills, student engagement, learning motivation, and metacognitive development. The distribution of these outcomes is presented in Table 7.

Table 7. Reported Learning Outcomes in the Reviewed Studies

Learning Outcome	Number of Studies	Percentage (%)
Learning Achievement	4	23.5
Conceptual Understanding	1	5.9
Scientific Work Skills	1	5.9
Student Engagement	1	5.9
Learning Motivation	1	5.9
Metacognitive Development	1	5.9

As shown in Table 7, learning achievement was the most frequently reported outcome. Studies conducted in chemistry, biology, physics, and elementary science education reported improvements in students' academic performance following the implementation of problem-solving learning.

Several studies also reported outcomes related to students' understanding and learning processes. Conceptual understanding and scientific work skills were identified in a study that implemented open-ended experimental activities. In this context, students engaged in investigating problems, interpreting evidence, and communicating the results of their investigations.

Other outcomes were reported in more specific instructional settings. Increased learning motivation was identified in an elementary school study, while student engagement was reported in a STEAM-based learning context. Metacognitive development was identified in a study that integrated self-regulated learning with problem-solving activities. The study focused on students' ability to monitor and regulate their own learning processes during problem solving.

These outcomes were reported across different educational contexts, although conceptual understanding, scientific work skills, student engagement, learning motivation, and metacognitive development were identified in a relatively small number of studies.

3.1.8. Reported Thinking Skills

The reviewed studies reported several thinking skills associated with the implementation of problem-solving learning. Critical thinking and creative thinking were the most frequently reported skills across the reviewed studies. Critical thinking was identified in studies conducted in chemistry, biology, health education, and STEAM education, whereas creative thinking was reported primarily in chemistry, science education, and STEM-related contexts. Several studies reported improvements in these skills following the implementation of problem-solving learning approaches.

In addition to critical and creative thinking, the reviewed studies also reported problem-solving skills, collaborative problem-solving, and metacognitive skills. Problem-solving skills were identified in studies conducted in chemistry, science education, and chemical engineering education, while collaborative problem-solving was reported in a chemistry learning context that integrated collaborative learning with problem-solving activities. Metacognitive skills were reported in a study that implemented self-regulated problem solving and examined students' ability to monitor and regulate their own learning processes. Overall, the reported thinking skills were concentrated in science-related disciplines, particularly chemistry, biology, physics, and science education, whereas evidence from other subject areas was comparatively limited.

3.1.9 Instructional Characteristics

Across the reviewed studies, problem-solving learning was implemented through a variety of instructional arrangements. Learning activities commonly began with problem situations that required students to analyze information, identify possible solutions, and justify their responses. In many science-related contexts, these problems were linked to scientific phenomena, experimental activities, or real-world situations.

Several studies incorporated inquiry and investigation as part of the learning process. This characteristic was evident in studies that used experimental activities, open-ended tasks, and STEM- or STEAM-based learning environments. Collaborative learning was also reported in a number of studies, particularly those that integrated discussion, dialogue, and group-based problem-solving activities.

The reviewed studies further showed the use of different forms of instructional support. These included multiple representations, interactive multimedia, digital simulations, and self-regulated learning strategies. Such supports were integrated into problem-solving activities in ways that reflected the subject area and instructional context of each study.

3.2 Discussion

3.2.1 Forms and Instructional Characteristics of Problem-Solving Learning

The reviewed studies reported a range of approaches to implementing problem-solving learning across different educational contexts. Creative Problem Solving (CPS) and its variants were the most frequently reported approaches. These approaches were identified in chemistry, biology, mathematics, health education, and nutrition science. Several studies adapted CPS by incorporating multiple representations, digital simulations, open-ended activities, and context-based learning tasks. This finding is consistent with previous research describing CPS as a flexible instructional framework that can be applied across different learning contexts and objectives (Setyosari et al., 2023).

Other approaches included collaborative problem-solving, multimedia-assisted problem solving, self-regulated problem solving, inquiry-based problem solving, Ethno-SETSaR problem solving, dialogic STEAM problem solving, and open-ended laboratory problem solving. While the approaches differed in their implementation, several common instructional features were observed. These included the use of contextual problems, inquiry activities, collaborative learning, and instructional supports such as multimedia, simulations, and multiple representations. Similar characteristics have also been discussed in the inquiry-based learning literature, particularly the emphasis on investigation, reasoning, and active student participation in knowledge construction (Chen & Chen, 2025; Arifin et al., 2025).

Technology-supported learning was also reported in several studies. Multimedia applications, digital simulations, and online learning environments were used to support students' engagement with problem situations and conceptual understanding. Similar findings have been reported by Affriyenni et al. (2020) and Lubis et al. (2025), who highlighted the contribution of simulation-supported learning environments to students' understanding of concepts during problem-solving activities.

Across the reviewed studies, problem situations commonly served as the starting point of learning activities. Students were expected to analyze information, consider alternative solutions, and justify their responses. These characteristics are consistent with constructivist and inquiry-based perspectives that emphasize active participation, reasoning, and knowledge construction during learning.

3.2.2 Learning Outcomes Associated with Problem-Solving Learning

The reviewed studies reported several learning outcomes associated with problem-solving learning. These outcomes included learning achievement, conceptual understanding, scientific work skills, student engagement, learning motivation, and metacognitive development. Among these outcomes, learning achievement was reported most frequently across the reviewed studies.

The reviewed studies commonly reported improvements in academic performance following the implementation of problem-solving learning. Learning activities that require students to analyze problems, evaluate information, and develop solutions may provide opportunities for deeper engagement with subject content. Similar findings have been reported by Unal and Cakir (2021), who found that technology-supported collaborative problem-solving was associated with higher achievement and student engagement. Khan et al. (2024) also reported a positive relationship between problem-solving skills, conceptual knowledge, and academic achievement in physics learning.

Several reviewed studies also reported outcomes related to students' understanding and learning processes. Conceptual understanding and scientific work skills were identified in studies that incorporated experimental and inquiry-oriented activities. These findings are consistent with previous research suggesting that problem-solving activities can support students' understanding of concepts while engaging them in investigation, evidence evaluation, and explanation building (Heliawati et al., 2021).

Learning motivation and student engagement were reported in a smaller number of studies. Nevertheless, these findings suggest that contextual and inquiry-oriented learning environments may

encourage students to participate more actively in learning activities. Similar observations have been reported in studies highlighting the role of problem-centered learning environments in supporting student engagement during instruction (Nemakhavhani, 2024).

Metacognitive development was also identified in one reviewed study that integrated self-regulated learning with problem-solving activities. This finding aligns with previous literature emphasizing the close relationship between self-regulation, reflection, and effective learning processes. Although reported less frequently, metacognitive development represents an outcome that may complement academic achievement and conceptual understanding within problem-solving learning environments.

3.2.3 Thinking Skills Associated with Problem-Solving Learning

The reviewed studies reported several thinking skills associated with problem-solving learning. Critical thinking and creative thinking were the most frequently reported skills, followed by problem-solving skills, collaborative problem-solving, and metacognitive skills. These findings are consistent with previous research that has highlighted the role of problem-solving activities in supporting reasoning, reflection, and the construction of solutions to complex problems.

Critical thinking was reported across chemistry, biology, health education, and STEAM education contexts. The reviewed studies commonly associated problem-solving learning with activities that required students to analyze information, evaluate evidence, and justify decisions. Similar findings were reported by Setiyowati and Shodikin (2022), who found that CPS-based learning supported students' critical thinking when responding to complex problem situations. Kuhn (2018) likewise emphasized the importance of discussion and evidence-based reasoning in the development of critical thinking.

Creative thinking was also reported in several studies, particularly those implementing CPS-based approaches. Students were often encouraged to generate alternative ideas and consider multiple solution pathways when responding to problem situations. This finding aligns with Ersoy and Özcan Kara (2026), who reported that CPS-based learning was associated with improvements in creative thinking through activities that promoted flexibility and idea generation.

In addition to critical and creative thinking, the reviewed studies reported the development of problem-solving skills, collaborative problem-solving, and metacognitive skills. These skills were identified in learning environments that emphasized inquiry, collaboration, and self-regulated learning. Abrenica (2025) similarly reported that problem-centered learning supported analytical reasoning and problem-solving processes, while Özcan (2016) highlighted the relationship between self-regulation, metacognitive processes, and problem-solving performance.

Overall, the reviewed studies associated problem-solving learning with a range of thinking skills. However, most of the available evidence originated from science-related disciplines, particularly chemistry, biology, physics, and science education. As a result, the applicability of these findings to other subject areas requires further investigation.

3.2.4 The Prominence of Chemistry Education in Problem-Solving Learning Research

One notable finding of this review is the prominence of chemistry education within the problem-solving learning literature. Chemistry represented the largest subject area among the reviewed studies and was examined across different educational levels. Although studies were also identified in biology, physics, mathematics, STEM/STEAM education, and health-related disciplines, chemistry appeared more frequently than any other subject area.

A possible explanation for this pattern relates to the instructional characteristics identified in the reviewed studies. Many chemistry topics involve abstract concepts that require students to connect observable phenomena with symbolic and submicroscopic representations. Students are often expected to interpret evidence, analyze relationships between concepts, and apply reasoning when solving

problems. These characteristics align closely with several problem-solving approaches reported in this review, particularly CPS-based, inquiry-oriented, and open-ended learning approaches.

Laboratory-based learning may provide another explanation for the prominence of chemistry education in the reviewed literature. Several studies implemented problem-solving learning through experimental investigations and open-ended activities. In these settings, students were required to collect and interpret evidence, evaluate alternative explanations, and justify their conclusions. Such learning processes reflect many of the instructional characteristics identified across the reviewed studies and are commonly embedded within chemistry instruction.

The reviewed studies also showed the use of multiple representations, simulations, and inquiry activities to support learning. These instructional features are frequently associated with chemistry education, where students are required to move between macroscopic observations, symbolic representations, and conceptual explanations. Previous studies have similarly emphasized the importance of representational competence and conceptual reasoning in chemistry learning (Ling et al., 2024; Permatasari et al., 2022).

Nevertheless, this finding should be interpreted with caution. Most studies included in this review were conducted in science-related disciplines, particularly chemistry, biology, physics, and science education. Therefore, the prominence of chemistry education in the reviewed literature does not necessarily indicate that problem-solving learning is more effective in chemistry than in other subject areas. Rather, it reflects the distribution of the available evidence identified in the reviewed studies.

3.2.5 Methodological Limitations of the Reviewed Studies

Several methodological limitations were identified across the reviewed studies. Many studies involved relatively small samples and short intervention periods. In addition, several studies employed pre-experimental or classroom-based designs, which provide a different level of evidence compared with studies that included control or comparison groups.

Variation was also observed in the measurement approaches used across studies. Researchers employed different instruments, including tests, questionnaires, observations, interviews, and performance assessments. This diversity reflects the broad range of outcomes examined, but it also makes direct comparisons across studies more difficult. Furthermore, few studies reported delayed posttests, limiting evidence regarding the long-term effects of problem-solving learning.

Another limitation concerns the reporting of effect sizes. Most studies emphasized statistical significance or reported improvements in outcomes, while information regarding the magnitude of these effects was often limited. Taken together, these methodological considerations suggest that the current evidence base should be interpreted with appropriate caution and would benefit from more rigorous and consistent research practices in future studies.

3.2.6 Educational and Research Implications

The reviewed studies suggest several implications for educational practice. Across the included studies, problem-solving learning was commonly implemented through contextual problems, inquiry activities, collaborative learning, and the use of instructional supports such as simulations, multimedia, and multiple representations. These findings indicate that teachers may consider incorporating such elements when designing learning activities that aim to engage students in reasoning, investigation, and solution development. However, the selection of instructional approaches should remain sensitive to subject content, student characteristics, and classroom conditions.

Several implications also emerge for future research. The reviewed studies were concentrated primarily in science-related disciplines, particularly chemistry, biology, physics, and science education. Additional research in mathematics, engineering, and other educational fields would help broaden the current evidence base. Future studies may also strengthen the quality of evidence by employing larger samples, longer intervention periods, delayed posttests, and more consistent reporting of effect sizes.

Greater consistency in measuring learning outcomes and thinking skills may further support comparisons across studies and contribute to a more comprehensive understanding of problem-solving learning.

4. CONCLUSION

This systematic literature review examined the implementation of problem-solving learning across different educational contexts. The reviewed studies suggest that problem-solving learning is commonly associated with the development of critical thinking, creative thinking, problem-solving skills, collaborative problem-solving, and metacognitive skills. In addition, problem-solving learning was associated with a range of learning outcomes, including learning achievement, conceptual understanding, scientific work skills, student engagement, learning motivation, and metacognitive development. The evidence identified in this review was concentrated primarily in science-related disciplines, particularly chemistry, biology, physics, and science education, with chemistry emerging as the most frequently represented subject area.

Several limitations should be considered when interpreting these findings. The reviewed studies varied in their research designs, sample sizes, intervention durations, and measurement approaches. In addition, delayed posttests and effect size reporting were limited in many studies. Future research should expand the evidence base to underrepresented subject areas, employ more rigorous methodological designs, and provide more consistent reporting of outcomes. Such efforts may contribute to a broader understanding of how problem-solving learning can be implemented across different educational contexts.

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