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How Do Students' Cognitive Style Influence Their Mathematical Problem-Solving Thinking Processess: A systematic Literature Review

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Abstract

This study aims to explore the influence of students' cognitive styles on the thought process in solving mathematical problems through a Systematic Literature Review (SLR) approach with PRISMA guidelines. Cognitive styles such as field-dependent vs. field-independent and reflective vs. impulsive are proven to influence the way students process information, represent mathematical concepts, and apply problem-solving strategies. A review of 10 selected articles showed that active learning models such as Project-Based Learning (PjBL) and Problem-Based Learning (PBL) are more effective when adapted to students' cognitive characteristics. Field-independent and reflective students tend to excel in analytical and logical thinking, while field-dependent and impulsive students perform better in collaboration when given appropriate scaffolding. The findings also suggest a link between cognitive styles and the development of 21st century skills, particularly critical thinking, creativity, communication and collaboration. This study recommends the importance of learning design that is responsive to individual differences to support the achievement of optimal learning outcomes.

Keywords: cognitive style, math problem solving, PjBL, PBL

Abstrak

Penelitian ini bertujuan untuk mengeksplorasi pengaruh gaya kognitif siswa terhadap proses berpikir dalam pemecahan masalah matematika melalui pendekatan *Systematic Literature Review* (SLR) dengan panduan PRISMA. Gaya kognitif seperti *field-dependent vs. field-independent* dan *reflective vs. impulsive* terbukti memengaruhi cara siswa memproses informasi, merepresentasikan konsep matematika, serta menerapkan strategi penyelesaian masalah. Tinjauan terhadap 10 artikel terpilih menunjukkan bahwa model pembelajaran aktif seperti *Project-Based Learning (PjBL)* dan *Problem-Based Learning (PBL)* lebih efektif bila disesuaikan dengan karakteristik kognitif siswa. Siswa *field-independent* dan reflektif cenderung lebih unggul dalam berpikir analitis dan logis, sedangkan siswa *field-dependent* dan impulsif menunjukkan performa lebih baik dalam kolaborasi jika diberikan scaffolding yang tepat. Temuan ini juga menunjukkan keterkaitan

antara gaya kognitif dan pengembangan keterampilan abad ke-21, khususnya berpikir kritis, kreativitas, komunikasi, dan kolaborasi. Studi ini merekomendasikan pentingnya desain pembelajaran yang responsif terhadap perbedaan individu untuk mendukung pencapaian hasil belajar yang optimal.

Kata kunci: gaya kognitif, pemecahan masalah matematika, PjBL, PBL

Introduction

Mathematical problem solving is a basic competency in education, which serves as a foundation for developing higher order thinking skills and promoting students' intellectual growth. However, students often face various challenges in solving complex mathematical problems, which can be influenced by individual differences such as cognitive style (Purnamasari et al., 2024). Cognitive style refers to an individual's preferred way of processing information, organizing knowledge, and approaching tasks, which can significantly affect learning outcomes (Habeaha et al., 2025). In the context of mathematics, understanding the interaction between cognitive styles and the problem-solving process is critical to designing effective learning strategies (Yanti et al., 2021). This systematic literature review aims to explore how students' cognitive style affects the thinking process in mathematics problem solving.

Several studies have shown that cognitive styles, particularly field-independent (FI) and field-dependent (FD) types, play an important role in shaping students' reasoning and problem-solving abilities (Setiawan et al., 2020). Field-independent students tend to analyze problems by breaking them down into components and applying various strategies, whereas field-dependent students often rely on contextual cues and relationships between elements (Herlina et al., 2024). These differences can result in varied approaches to solving mathematical tasks, with FI students generally demonstrating stronger analytical abilities (Setiawan et al., 2020). Such insights highlight the need for educators to recognize and accommodate diverse cognitive preferences in the classroom (Habeaha et al., 2025). As such, teachers can better support students in developing strong problem-solving skills.

The influence of cognitive style extends to the types of mathematical representations students use when solving problems (Salam, 2023). For example, reflective students often use a variety of representations-such as geometric, verbal, and symbolic-while impulsive students may focus more on symbolic representations and struggle with accuracy and translation between forms (Salam, 2023). These tendencies impact not only the process but also the quality of students' solutions. Understanding these patterns can inform the development of targeted interventions to improve students' representational flexibility. Ultimately, this contributes to improved mathematical understanding and performance.

Adaptive reasoning, defined as the ability to justify strategies and solutions, is closely related to cognitive style and mathematical problem solving (Yanti et al., 2021). Students with different cognitive styles may exhibit different reasoning profiles, which influence how they construct arguments and validate their solutions (Yanti et al., 2021). For example, FI students are often better able to provide logical explanations and connect mathematical concepts, whereas FD students may require additional scaffolding to reach the same level of reasoning (Herlina et al., 2024). This relationship underscores the importance of aligning instructional approaches with students' cognitive characteristics. Such alignment can promote deeper engagement and a more effective learning experience.

Problem-based learning (PBL) environments further illustrate the impact of cognitive style on math problem solving. Research shows that students with analytical cognitive styles excel at abstraction and problem solving in PBL environments, while students with holistic styles may require more guidance (Habeaha et al., 2025). These findings suggest that flexible and inclusive teaching methods are needed to accommodate the diverse cognitive profiles present in any classroom. By capitalizing on students' strengths and addressing their challenges, educators can maximize learning potential and foster mathematical resilience.

Although research on this subject is growing, there are still gaps in understanding the specific thought processes underlying mathematical problem

solving across different cognitive styles (Herlina et al., 2024). Most research focuses on comparing overall performance rather than examining the step-by-step cognitive processes involved (Herlina et al., 2024). Addressing this gap is critical to developing a comprehensive theory of mathematical thinking that accounts for individual differences (Herlina et al., 2024). Such knowledge can inform the design of diagnostic tools and instructional materials tailored to students' cognitive profiles. This review seeks to synthesize existing findings and identify directions for future research.

The role of metacognition in mathematics problem solving is also influenced by cognitive style (Herlina et al., 2024). Students who have a field-independent cognitive style often show greater metacognitive awareness, allowing them to monitor and regulate their thinking more effectively during problem solving (Herlina et al., 2024). In contrast, teacher-dependent students may benefit from explicit scaffolding to develop these skills (Herlina et al., 2024). Improving metacognitive abilities across cognitive styles can lead to more strategic and reflective problem-solving behaviors. Therefore, integrating metacognitive training into mathematics learning is highly recommended.

Cognitive style affects not only how students solve problems, but also their ability to transfer knowledge to new contexts (Habeaha et al., 2025). Analytical students are generally more adept at applying learned strategies to unfamiliar problems, while holistic students may struggle to generalize their knowledge (Habeaha et al., 2025). These differences have implications for curriculum design and assessment practices. Providing varied problem types and encouraging flexible thinking can help bridge this gap and promote equitable learning outcomes.

In addition, the interaction between cognitive style and other individual factors, such as emotional intelligence and learning disposition, needs to be further investigated (Yanti et al., 2021). These factors together may influence students' engagement, perseverance and success in mathematical problem solving (Yanti et al., 2021). A holistic approach to research and practice can lead to more nuanced

insights into the complexities of mathematics learning. By considering the multiple dimensions of individual differences, educators can better support all students. In short, understanding how students' cognitive styles influence thought processes in solving mathematical problems is critical to advancing educational practice and research. This systematic literature review synthesizes current evidence, highlights key findings and identifies areas for further exploration. The insights gained can inform the development of different learning strategies, ultimately supporting students to become proficient and confident problem solvers.

Methology

This study aims to evaluate how cognitive style affects the effectiveness of project-based learning, problem-based learning, reflective learning, and other interventions in improving critical thinking skills, creativity, and collaboration and communication among students and prospective teachers. This study used the Systematic Literature Review (SLR) method with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guideline approach to identify, evaluate, and synthesize relevant scientific articles related to students' mathematics education approaches. The steps in this process are described as follows:

1. Identification of Research Questions

   The main questions in this review are How does cognitive style influence the development of critical thinking skills and creativity and what learning strategies are most effective for learners with certain cognitive styles.

2. Inclusion Criteria

   Inclusion criteria in this study are as follows; 1) Articles published in accredited scientific journals, 2) Focus on the field of education, especially teachers / students. 3) Discussing cognitive styles (for example, field-dependent/independent, reflective/impulsive). 4) Based on active learning approach (PjBL, PBL, e-learning, etc.).

3. Sourcing and Search Strategies

TITLE-ABS-KEY ("cognitivestyle" OR "field dependent") AND PUBYEAR > 2014 AND PUBYEAR < 2026 AND (LIMIT-TO (SUBJAREA , "PSYC") OR LIMIT-TO (SUBJAREA , "MATH")) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (PUBSTAGE , "final")) AND (LIMIT-TO (SRCTYPE , "j")) AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (OA , "all")) AND (LIMIT-TO (AFFILCOUNTRY , "Indonesia"))

PRISMA Selection process

1) Searching for articles in the Scopus database using keywords ("Cognitive Style" OR "Field Dependent") found 6,767 documents.
2) Filtering on the year of publication, namely between 2015-2025 found 1,208 documents.
3) Filtering on Subject area, i.e. "Psyc" and "Math", 927 documents were found.
4) Filtering on Pubstage, i.e. "Final" 904 documents remaining
5) Filtering articles, which are selected are studies in the form of articles, and obtained 854 documents
6) Filtering on the language used. In this study, selected articles on the Scopus data base with English, and obtained 393 remaining documents.
7) Filtering again by selecting articles originating from Indonesia (AFFILCOUNTRY, "Indonesia"), 12 documents remain.
8) 12 documents that have been obtained then selected only open access articles are used, and obtained 10 articles which are then analyzed.

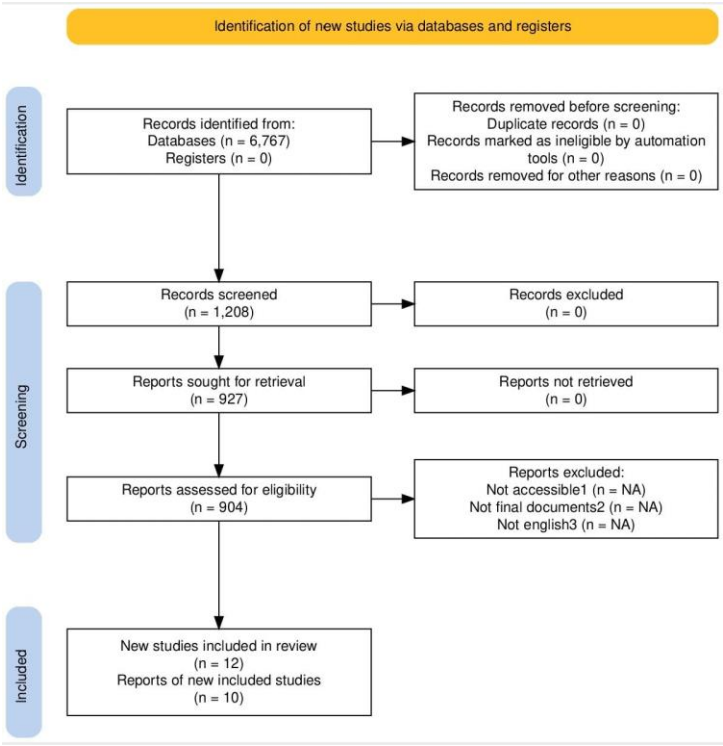

Figure 1. *PRISMA Diagram*

4. Data Extraction and Analysis

Data from each selected article was extracted into an analysis matrix, including: 1) Title, author, year of publication, journal, 2) Research methods and instruments, 3) Population and subjects, 4) Main findings, and 5) Thematic focus. Analysis was conducted using a thematic approach to identify patterns, gaps, and contributions of each study to cognitive development.

Discussion

To strengthen the theoretical foundation and support the relevance of the research, a number of previous studies related to cognitive style, creativity, problem-based learning, and collaborative and evaluative aspects in educational contexts were searched. The following table summarizes the main themes, general findings and references from the relevant studies:

Table 1. Article Anaysis

Themes	Finding	Reference
1. Cognitive Style and Creativity	Field-independent and reflective styles are more likely to produce creative solutions when using project-based learning models.	(Setiyani *et al*., 2025)
2. Problem-based Learning and Critical Thinking	*Problem-Based Learning (PBL) and e-learning were shown to improve critical thinking in students, especially when matched with their cognitive styles.*	(Lubna *et al*., 2023)
3. Collaboration and Communication	Students with reflective styles showed stronger cooperation and communication in collaborative tasks, such as writing scientific papers.	(Cintamulya *et al*., 2024)
4. Creativity and Motivation Interventions	Program interventions (such as FPSPI) successfully increased students' creativity representation and learning motivation.	(Jesus *et al,*, 2015)
5. Program Evaluation and Logic Model	Logic evaluation of educational models shows that outcome-based strategies are more systematically measurable.	(Booker, 2020)
6. Quality Assurance in the Vocational Context	Internal quality assurance systems strengthen the planning and implementation of learning programs that are responsive to student needs.	(Zahrok, 2020)
7. Student Perceptions of the English Program	Adjustment of teaching programs to students' cognitive needs increases positive perceptions of learning..	(Aldaihani *et al.*, 2015)

Learning approaches that consider cognitive styles, such as reflective-impulsive and field-dependence/independence, show significant impact on learning outcomes, especially in critical thinking, creativity, collaboration and communication. PjBL, PBL (Problem-Based Learning), and problem-based e-learning models are the most frequently used methods and proven effective when associated with students' cognitive characteristics. Systematic interventions and logic-based evaluation models are essential for the long-term effectiveness of educational programs. Analytical SLR on cognitive styles and 21st century skills are shown in Table 2 below.

Table 2. SLR Analytis

No	Title & year	Method	Cognitive Style	Subject	Findings	Implications
1	*Implementation of Project-Based Learning...* (Harjono, 2024)	quantitative (pre-posttest)	Field Dependent (FD), Field Independent (FI)	40 physics teacher candidates	PjBL increases creativity, more significantly in FDpada FD	PjBL is suitable for FD in creative media development
2	*Assessing Students' Critical Thinking Skills* (Evendi *et al*., 2022)	Evaluative experimental	FD vs FI	28 math students	e-PBL is effective in improving CT for all styles	e-PBL is recommended as the main approach
3	*Optimizing Collaboration and Communication Skills...* (Cintamulya *et al*,, 2024)	Mixed Methods	Reflective vs Impulsive	10 biology students	Impulsive excels in collaboration; reflective stronger in some aspects of communication	Scientific assignments effectively train collaborative-communicative skills
4	*Evaluation of STEM Students' Critical Thinking...* (Lubna *et al*., 2023)	evaluative (Model Kirkpatrick)	FD vs FI	STEM students	PBDL (Problem-based Distance Learning.) effective at improving CT regardless of cognitive style	PBDL (Problem-based Distance Learning) recommended for STEM distance learning
5	*Lateral Thinking in Math Word Problems* (Nur *et al*., 2022)	Deskriptif qualitative	Reflective	Junior high school students	Reflective style improves lateral problem solving	Support flexible thinking learning through realistic contexts
6	*Scaffolding & Reflective*	Case studi	Field Dependent	7 th grade (2	DF students have difficulty	Differentiation & scaffolding

	Thinking in Numeracy... (Setiyani *et al.,* 2025)			student s)	understandi ng numerical context without scaffolding	approaches are essential
7	*Implementa si SPMI di SMK* (Zahrok, 2020)	Kualitatif	_	vocatio nal schools	SNP-based quality evaluation through EDS and quality documents	SPMI (internal quality assurance system) strengthens internal quality controlinter nal
8	*Intervention Program on Creativity and Motivation* (Jesus *et al,*, 2015)	Longitudi nal (pre-posttest)	Not specific	155 junior high school student s	FPSPI improves creativity representati on & motivation	Systematic interventio ns impact students' creative beliefs
9	*A Revised Logic Model for Educational Evaluation* (Booker, 2020)	Theoretic al-Conceptu al	Not relevant	—	Logic models reinforced with contextual cause-effect relationship s	Suitable for evaluation of outcome-based education programs
1 0	*Students' Perceptions of the Effectivenes s..* (Aldaihani *et al.,* 2015)	Survey	-	242 student s	Students are satisfied with the results of the English program, but there are implementa tion short comings	Need to evaluate methods and instructors for continuous improveme nt

Based on 10 articles reviewed, it shows that 4 studies compared field-

dependent and field-independent styles (FD vs FI) in the context of active learning (PjBL, e-PBL, PBDL). Furthermore, 2 studies examined reflective vs impulsive styles, especially in scientific writing and collaboration tasks. And 1 study focused on field dependent style and numerical reflection. The rest do not mention explicitly cognitive style (eg program evaluation studies or quality of education). Based on this, it can be concluded that cognitive style is proven to affect learning strategies and outcomes. For example, students with FD style showed a more significant increase in creativity when using the PjBL model. Impulsive students have an advantage in collaboration skills over reflective.

Various approaches were used in the reviewed studies, with Project-Based Learning (PjBL) and Problem-Based Learning (PBL) emerging as the dominant methods. e-learning and distance learning were used for digital/online contexts. Scaffolding and reflective assignments were used to support low-ability students. Active methods such as PjBL and PBDL are shown to be effective in enhancing creativity and critical thinking, especially when adapted to students' cognitive styles.

Some articles do not directly address 21st-century skills but are important in terms of education management, such as SPMI (Internal Quality Assurance System) in SMK as a framework for continuous improvement. An evaluative logic model for designing and evaluating educational programs holistically. Student perceptions of the English program as an important reflection of curriculum effectiveness. Systematic and participatory program evaluation is an important foundation to support long-term achievement of 21st century skills.

Cognitive style has a strong relationship with the effectiveness of 21st century skill development, especially in active learning. PjBL and PBL are effective approaches when matched with students' cognitive characteristics. Critical thinking and creativity are the two most researched skills, suggesting that they are prioritized in educational innovation. Data-driven evaluation and logic models are needed to measure the impact of learning and design more appropriate educational programs.

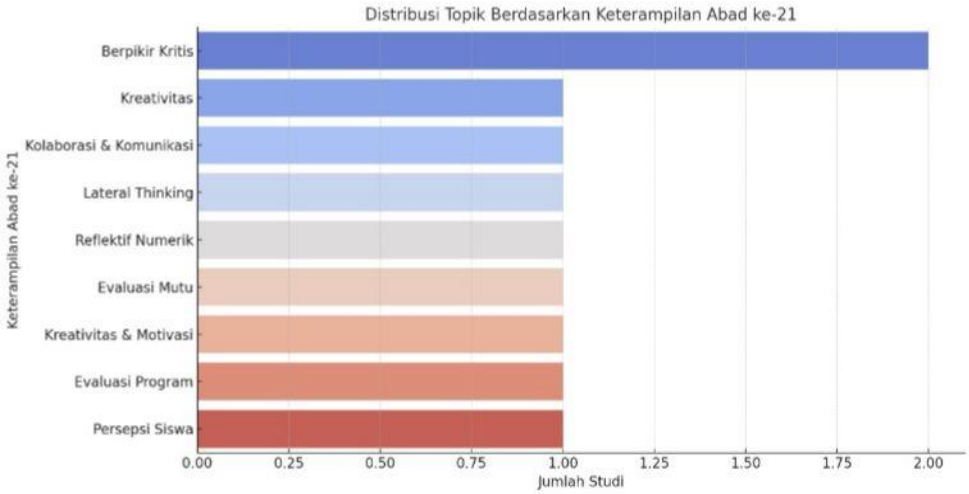

Figure 2. Visualization of Research Topic Distribution Graph

Based on the graph visualization, there is a dominance of 21st century skills themes examined as follows; Critical Thinking was the main focus in 3 studies (30%), particularly in STEM and mathematics contexts; Creativity appeared in 2 main studies (20%), often associated with field-dependent (FD) cognitive styles and project-based learning (PjBL) approaches; Collaboration and Communication were discussed in 1 exploratory study on biology students with reflective and impulsive styles; Other skills such as lateral thinking, numerical reflection, academic motivation, and program evaluation also appeared, each in one study. Research in the last decade shows a strong tendency to link critical thinking and creativity as the main targets of cognitive-based learning. This is in line with the need for complex competencies in the digital era.

Recent studies confirm that critical thinking is one of the key skills to be developed in 21st century learning, especially in the context of STEM and mathematics. STEM learning significantly improves critical thinking skills through a real-world problem-solving process, enabling students to logically analyze information and solve problems with data-driven solutions (Redhana, 2019). Collaboration and communication skills are also a concern in exploratory studies, particularly in biology students with reflective and impulsive styles. These two

skills are part of the 4Cs (Critical thinking, Creative thinking, Communication, Collaboration) that are crucial in 21st century learning, helping students to learn more effectively and develop valuable social skills for later life (Thahir et al., 2024). Studies in the last decade show a strong trend to link critical thinking and creativity as the main targets of cognitive-based learning. This is in line with the needs of the world of work and society which increasingly demand higher-order thinking skills, innovation, and adaptation to rapid change in the digital era and industrial revolution 4.0 (Supriandi, 2023).

Conclusion

This systematic literature review shows that students' cognitive styles (such as field-dependent vs. field-independent and reflective vs. impulsive) have a significant influence on thinking processes and strategies in mathematical problem solving, as well as the development of 21st century skills such as critical thinking, creativity, collaboration and communication. Cognitive style affects students' approach to solving mathematical problems, both in terms of representation, adaptive reasoning, and metacognitive abilities. Students with field-independent and reflective styles tend to be more analytical and accurate in problem solving, while field-dependent and impulsive students often require additional support (scaffolding) and perform better in collaboration. Active learning models such as Project-Based Learning (PjBL), Problem-Based Learning (PBL), e-learning, and reflective learning are proven to be more effective when tailored to each student's cognitive style. Problem- and project-based learning significantly improved critical thinking skills and creativity, especially in students with certain cognitive styles. Logic-based program evaluation and internal quality assurance systems are needed to ensure adaptive and sustainable learning to student needs.

Teachers and educators need to recognize and adapt learning strategies to students' cognitive styles to optimize the learning process and academic outcomes. Metacognitive interventions and scaffolding are strongly recommended to support students in developing more reflective and adaptive problem-solving strategies.

Curriculum design and assessment should be flexible and responsive to individual differences, in order to achieve inclusive and equitable learning.

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