

Profile of Junior High School Students' Critical Thinking Skills in Solving Geometric Problems Based on Cognitive Styles

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Abstract

Critical thinking is a fundamental competency in mathematics education, particularly in geometry, where students must interpret, analyze, evaluate, and draw inferences from abstract representations; however, these abilities can be influenced by differences in cognitive styles. This study examines the critical thinking profiles of eighth-grade students in solving plane geometry problems by exploring how field-independent (FI) and field-dependent (FD) cognitive styles shape problem-solving processes and outcomes. Cognitive styles were identified using the Group Embedded Figures Test (GEFT), and four students representing FI and FD styles with equivalent mathematical ability were purposively selected. Data were collected through geometry problem-solving tests and semi-structured interviews based on four indicators of critical thinking: interpreting, analyzing, evaluating, and inferring. The results show that FI students demonstrated more systematic, reflective, and autonomous problem-solving approaches, effectively integrating all critical thinking indicators. In contrast, FD students performed adequately in interpretation and basic analysis but experienced difficulties in higher-level processes, particularly evaluation and inference. Inference was identified as the most challenging indicator for students in both cognitive style groups. These findings underscore the influence of cognitive style on students' critical thinking in geometry and highlight the need for differentiated instructional strategies. Open-ended tasks can support autonomy and deeper reasoning for FI students, while structured scaffolding and guided support are crucial for helping FD students develop higher-order thinking skills and achieve more equitable learning outcomes.

Keywords: *Critical Thinking Skills; Cognitive Style; Field-Independent; Field-Dependent*

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INTRODUCTION

Mathematics is a fundamental discipline that underpins logical reasoning, problem-solving, and cognitive development. Beyond memorizing formulas, mathematics engages students in systematic, critical, and creative thinking, providing opportunities to analyze, evaluate, and construct solutions (Afnia & Setyawan, 2021; Agustiana & Imami, 2021). Among these competencies, critical thinking is particularly essential, as it enables students to process information rigorously, make reasoned decisions, and solve problems efficiently (Afriansyah, et al., 2021; Amini, et al., 2019). The development of critical thinking aligns with 21st-century education goals emphasizing 4C skills (*critical thinking, creativity, communication, and collaboration*) preparing learners to face complex challenges in academic and real-life contexts (Wati, et al., 2024).

Despite its importance, numerous studies indicate that Indonesian students' critical thinking skills in mathematics remain inadequate. Research has documented weaknesses in reasoning, problem analysis, and evaluation across mathematical topics, including geometry, algebra, and arithmetic (Anggraini, et al., 2022; Jannah & Budiman, 2022). Geometry, in particular, demands higher-order thinking skills (HOTS), as students must visualize shapes, analyze spatial relationships, and apply formulas to novel problems (Nurhayati, et al., 2022; Ayu, et al., 2023). International assessments such as PISA and TIMSS corroborate these findings, showing that Indonesian students lag behind peers in mathematical problem-solving and reasoning (Cahyono, et al., 2022; Faradina, et al., 2019). This gap highlights the urgent need to investigate factors that influence students' critical thinking performance in mathematics, particularly geometry.

One significant factor affecting critical thinking is cognitive style, defined as the consistent individual preference in processing and organizing information (Fuadi & Walidin, 2024). Cognitive styles influence how students approach mathematical problems, determine strategies, and adapt to novel situations (Arifah, et al., 2022). Two primary types are widely recognized: *field-independent* (FI) and *field-dependent* (FD) learners. FI students tend to analyze information systematically, rely on internal cues, and demonstrate flexibility in problem-solving. In contrast, FD students are more dependent on external guidance, often struggle with abstract reasoning, and may face challenges in adapting strategies to new problems (Anggraini et al., 2022; Nurmaliza, et al., 2022). Prior studies suggest that FI learners generally exhibit higher mathematical achievement and more advanced critical thinking skills compared to FD peers (Amini et al., 2019; Marthaliakirana, et al., 2022). Understanding cognitive style is therefore crucial for optimizing instruction and supporting students in developing critical thinking, particularly in geometry, which involves abstract and spatial reasoning.

Geometry offers a rich context for cultivating critical thinking, as it requires reasoning, visualization, and the ability to generalize concepts to solve unfamiliar problems (Nurhayati et al., 2022; Wasqita, et al., 2022). Plane-sided shapes, typically introduced in junior high school, serve as a foundation for understanding surface area, volume, and spatial relationships, which have practical applications in daily life, such as object design and measurement (Tahir, et al., 2022). However, students frequently encounter difficulties in tasks requiring HOTS, such as constructing proofs, solving non-routine problems, or applying reasoning strategies flexibly (Agustiana & Imami, 2021; Ayu et al., 2023). These difficulties indicate a need to examine students' critical thinking processes, including skills in reasoning, inference, problem analysis, evaluation, and clarity, in connection with their cognitive style.

The existing literature demonstrates that cognitive style and learning preferences influence students' success in problem-solving and HOTS tasks (Cahyono et al., 2022; Wati et al., 2024). FI learners are more adept at analyzing complex geometric problems, selecting appropriate strategies, and generating logical solutions, whereas FD learners may struggle to integrate prior knowledge or adapt to abstract contexts (Amini et al., 2019; Arifah et al., 2022). Despite the recognition of these differences, research specifically examining the relationship between cognitive style and critical thinking in geometric problem-solving remains limited. Most studies focus either on general mathematics critical thinking (Hidayanto, et al., 2022; Nurmaliza et al., 2022) or on students' performance in geometry without considering cognitive styles (Jannah & Budiman, 2022; Nurhayati et al., 2022). This gap underscores the necessity of

exploring the interaction between cognitive style and critical thinking in geometry to inform differentiated instruction and curriculum design.

Critical thinking in mathematics encompasses a set of cognitive processes, including logical reasoning, analyzing assumptions, evaluating evidence, and making justified conclusions (Anggraini et al., 2022; Anita & Firmansyah, 2022). It allows students not only to solve routine problems but also to interpret, classify, and evaluate ideas critically, thereby fostering independent and creative thinking (Hidayanto et al., 2022; Nurmaliza et al., 2022). In geometry, these processes manifest through activities such as proving relationships, classifying shapes, comparing properties, and generalizing patterns (Agustiana & Imami, 2021; Ayu et al., 2023). By measuring critical thinking through indicators such as focus, reasoning, inference, clarity, and review, educators can identify students' strengths and weaknesses and tailor instruction to address specific learning needs (Anggraini et al., 2022; Afriansyah et al., 2021).

Based on this theoretical and empirical foundation, the present study aims to analyze junior high school students' critical thinking skills in solving geometric problems based on cognitive styles, specifically comparing FI and FD learners. This research addresses a persistent educational gap, linking students' cognitive profiles to their problem-solving abilities in geometry. The study is expected to provide both theoretical contributions, by elucidating the relationship between cognitive style and critical thinking in mathematics education, and practical implications, by guiding teachers in implementing differentiated instruction, designing HOTS-based tasks, and enhancing students' capacity for logical, independent, and creative problem-solving. Ultimately, developing students' mathematical critical thinking is essential to prepare them as capable problem solvers who can apply mathematics meaningfully in real-world contexts (Ayu et al., 2023; Nurhayati et al., 2022; Wasqita et al., 2022).

METHOD

This study employed a qualitative descriptive approach aimed at portraying the critical thinking skills of junior high school students in solving geometric problems based on cognitive style. The research was conducted at SMP Bina Citra Makassar during the even semester of the 2024–2025 academic year, focusing on grade VIII students who had studied the relevant geometric material. Participants were selected using purposive sampling, considering both cognitive style and gender, resulting in four students: one male and one female with a field-dependent (FD) cognitive style, and one male and one female with a field-independent (FI) cognitive style. All participants had relatively equivalent mathematical abilities, as verified by the mathematics teacher, and their cognitive styles were identified using the standardized Group Embedded Figures Test (GEFT). This selection aimed to examine potential differences in critical thinking between male and female students across distinct cognitive styles.

The research instruments included a mathematical critical thinking test, interview guidelines, and a cognitive style assessment. The critical thinking test consisted of four validated descriptive questions designed to collect quantitative data on students' problem-solving abilities, while interviews provided qualitative insights into their reasoning processes, strategies, and decision-making during problem solving. The procedure involved administering the critical thinking test to all grade VIII students, categorizing their performance as high, medium, or low based on the criteria proposed by Nurmaliza et al. (2022), and selecting one representative student per category for each cognitive style and gender. Subsequently, in-depth interviews were conducted to explore their thinking patterns and problem-solving approaches.

Data were analyzed following Miles and Huberman's (1994) framework, comprising three stages: data reduction, data display, and drawing conclusions. During data reduction, irrelevant information was filtered out to focus on meaningful insights. Data were then organized through tables, charts, and narrative descriptions to facilitate interpretation. Finally, conclusions were drawn to profile students' critical thinking in solving geometric problems based on cognitive style. Quantitative test results identified the level of critical thinking, while qualitative interview data revealed strategies, cognitive processes, and challenges encountered. Data validity was ensured through triangulation, comparing test results, interviews, and teacher observations. This comprehensive approach provides a detailed understanding of critical thinking profiles among grade VIII students at SMP Bina Citra Makassar and highlights differences associated with cognitive style and gender, offering practical implications for designing more effective and individualized instructional strategies.

RESULT AND DISCUSSION

This study investigated the critical thinking skills of eighth-grade students at SMP Bina Citra Makassar in solving plane geometry problems by examining differences between field-independent (FI) and field-dependent (FD) cognitive styles. Cognitive styles were identified using the Group Embedded Figures Test (GEFT), which classified 7 students (35%) as FI and 13 students (65%) as FD, indicating that most students tended to rely on external cues and guidance when processing information, while a smaller group demonstrated greater analytical autonomy. From this population, four students with comparable mathematical abilities were purposively selected to represent each cognitive style: two FI students and two FD students. Data were collected through written geometry problem-solving tests and in-depth interviews based on four critical thinking indicators adapted from Ennis, namely interpreting, analyzing, evaluating, and inferring. These indicators were used to examine how students identify known information, construct mathematical models, assess solution strategies, and draw logical conclusions. The cognitive style classification provided a foundation for analyzing variations in students' critical thinking performance. By comparing FI and FD students, this study reveals how differences in analytical independence and reliance on external guidance influence students' systematic engagement with plane geometry problems, offering both quantitative and qualitative insights into the relationship between cognitive style and critical thinking in mathematics learning.

Table 1. Distribution of Cognitive Styles

Cognitive Style	Number of Students	Percentage
Field-Dependent (FD)	13	65%
Field-Independent (FI)	7	35%
Total	20	100%

Students' critical thinking skills were evaluated using four descriptive plane geometry problems designed to measure four indicators adapted from Ennis, namely interpreting, analyzing, evaluating, and inferring. Each problem was aligned with one dominant indicator to ensure focused assessment of specific aspects of critical thinking. Students' responses were examined in depth and analyzed based on their cognitive styles to identify differences in problem-solving approaches and reasoning processes. The analysis considered not only the

accuracy of answers but also the clarity of mathematical representations, the logic of solution strategies, and the justification of conclusions.

Table 2. Critical Thinking Performance by Cognitive Style

Indicator	FI Students (n=7)	FD Students (n=13)
Interpreting	100%	85%
Analyzing	93%	62%
Evaluating	87%	58%
Inferring	71%	31%

As shown in Table 2, FI students consistently outperformed FD students across all indicators. FI learners demonstrated strong abilities in problem modeling, strategy implementation, and conclusion drawing, reflecting systematic and independent reasoning. FD learners, while capable of identifying known elements and performing guided calculations, struggled with inferential reasoning and evaluation, often relying on memorized procedures or external prompts.

The inferring indicator was the most challenging for all students, particularly FD learners, with only 31% achieving correct conclusions. This aligns with prior research indicating that drawing generalizations and inferences from problem-solving results is commonly difficult, even for higher-performing students (Amini, et al., 2019; Hidayanto et al., 2022). In contrast, interpreting showed the highest achievement across both groups, indicating that students could generally identify known information and understand problem statements.

To deepen understanding, four students were purposively selected as case subjects based on cognitive style and similar mathematical ability: T-1 (male FI), T-2 (female FI), S-1 (male FD), and R-1 (female FD). Interviews revealed qualitative differences that complemented the quantitative findings.

Table 3. Qualitative Profile of Selected Students

Student	Cognitive Style	Key Strengths	Challenges
T-1	FI	Full interpretation, analysis, evaluation, and inference	<ul style="list-style-type: none"> Minor errors in verification
T-2	FI	Accurate interpretation and analysis	<ul style="list-style-type: none"> Omitted conclusion in one problem; Incomplete calculation in another
S-1	FD	Correctly interpreted and analyzed problems	<ul style="list-style-type: none"> Struggled with evaluation and inferring conclusions
R-1	FD	Identified known items in some problems	<ul style="list-style-type: none"> Poor analysis, evaluation, and inference; Lacked conceptual understanding

Field-Independent (FI) Students (T-1, T-2)

FI students demonstrated sharp, systematic, and autonomous critical thinking when solving plane geometry problems. They consistently translated verbal problem statements into accurate mathematical representations, independently selected appropriate solution strategies, and articulated logical conclusions. T-1 satisfied all four critical thinking indicators: interpreting, analyzing, evaluating, and inferring, across tasks, reflecting strong metacognitive awareness and integrated reasoning. This student not only executed procedures correctly but also monitored solution processes and justified results with clarity. T-2 exhibited a comparable level of analytical independence; however, minor procedural weaknesses were observed. Specifically, T-2 omitted an explicit conclusion in one task and failed to complete calculations

in another, indicating lapses in solution closure rather than conceptual misunderstanding. Despite these limitations, T-2's reasoning process remained coherent and strategically sound. Overall, the performance of both FI students provides compelling evidence that analytical autonomy plays a critical role in fostering higher-order thinking. Such autonomy enables students to regulate their cognitive processes effectively and supports accurate, efficient problem-solving in plane geometry.

Field-Dependent (FD) Students (S-1, R-1)

FD students exhibited partial and unsystematic critical thinking when solving geometric problems. S-1 was able to interpret and analyze relatively simple tasks but struggled at the evaluation stage when confronted with multi-step or non-routine problems, such as determining the geometry of a cuboid with a pyramid roof. Interview data indicated that S-1 depended on repeated reading and external prompts to identify key information and determine solution strategies, suggesting limited independence in reasoning. In contrast, R-1 demonstrated minimal critical thinking across all indicators. This student experienced persistent difficulty translating problem statements into mathematical representations, executing calculations accurately, and formulating valid conclusions. Collectively, these findings indicate that FD learners rely heavily on external scaffolding and face substantial obstacles in tasks requiring autonomous reasoning, corroborating prior studies on the influence of cognitive style on mathematical problem-solving (Arifah et al., 2022; Marthaliakirana et al., 2022).

Overall, the findings confirm that cognitive style significantly influences eighth-grade students' critical thinking in solving plane geometry problems at SMP Bina Citra Makassar. FI students consistently demonstrated comprehensive and reflective problem-solving behaviors, integrating interpretation, analysis, evaluation, and inference in a systematic manner. Their ability to independently model problems, select effective strategies, and justify conclusions reflects strong analytical reasoning and metacognitive control. Conversely, FD students showed a strong dependence on procedural guidance and structured support, particularly struggling with tasks that demanded independent inference. This contrast aligns with earlier research indicating that FI learners tend to excel in higher-order and non-routine problem-solving, whereas FD learners benefit more from scaffolded and step-by-step instructional approaches (Amini et al., 2019; Marthaliakirana et al., 2022; Arifah et al., 2022).

Notably, the inferential indicator emerged as the most challenging across cognitive styles, including among high-performing FI students. This suggests a general difficulty in transforming procedural solutions into coherent conclusions or conceptual generalizations. Pedagogically, these results underscore the importance of differentiated instruction based on cognitive style. Open-ended and complex tasks can further enhance FI students' autonomy and strategic thinking, while guided problem-solving and targeted scaffolding are essential for strengthening FD students' inferential reasoning. Integrating cognitive-style awareness into geometry instruction enables teachers to design equitable learning experiences and supports the development of comprehensive critical thinking skills aligned with 21st-century educational goals (Ayu et al., 2023; Wasqita et al., 2022).

CONCLUSION

This study presents a comprehensive profile of eighth-grade students' critical thinking skills in solving plane geometry problems at SMP Bina Citra Makassar by examining differences in cognitive style. The findings indicate that cognitive style plays a significant role in shaping critical thinking performance. Field-independent (FI) students consistently demonstrated systematic, reflective, and autonomous problem-solving, effectively integrating interpretation, analysis, evaluation, and inference. In contrast, field-dependent (FD) students performed adequately in interpreting problems and executing basic calculations but experienced difficulties in evaluating multi-step tasks and formulating conclusions, indicating a reliance on structured guidance and procedural knowledge.

Across all participants, the inferential indicator emerged as the most challenging, emphasizing the need for explicit instructional support in reasoning and generalizing solutions. These results highlight the importance of differentiated instruction aligned with students' cognitive styles. FI students benefit from open-ended and complex tasks that promote strategic thinking and higher-order reasoning, whereas FD students require scaffolded and guided problem-solving to strengthen inferential and evaluative skills. Pedagogically, integrating cognitive-style awareness into geometry instruction can enhance equity in learning and support the development of comprehensive critical thinking and problem-solving competencies in mathematics.

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