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Critical thinking of impulsive students in solving geometry problems

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Abstract

Critical thinking is a higher-order thinking skill that plays a crucial role in mathematics education, particularly in geometry, which requires students to analyze relationships among objects, evaluate solution procedures, and construct logical arguments. However, students with an impulsive cognitive style tend to respond hastily, demonstrate insufficient accuracy, and frequently commit both procedural and conceptual errors in problem solving. This study aims to describe the critical thinking abilities of students with an impulsive cognitive style in solving geometry problem-solving tasks, especially those requiring reasoning about the properties of plane figures and the relationships among geometric elements. This study employed a descriptive qualitative approach involving two ninth-grade junior high school students as research participants. The participants were selected based on the results of the Matching Familiar Figures Test (MFFT), with fast response time and a high number of errors serving as the dominant indicators of an impulsive cognitive style. The research instruments consisted of a geometry problem-solving test and in-depth interview guidelines. Data analysis focused on Ennis's critical thinking indicators, namely: (1) clarity of statements, (2) the basis for decision making, (3) procedural and computational accuracy, and (4) evaluation of solutions. The findings indicate that impulsive students exhibit dominant weaknesses in the indicators of clarity of reasoning, computational accuracy, and solution evaluation. They tend to determine solution steps hastily without re-examining the procedures used. Nevertheless, with respect to the indicator of identifying relevant information, impulsive students still demonstrate relatively adequate ability. They are also able to formulate problem-solving strategies; however, these strategies tend to be unsystematic and often fail to consider alternative approaches.These findings confirm that an impulsive cognitive style has a significant influence on the quality of students' critical thinking in geometry problem solving. The pedagogical implications of this study highlight the need for teachers to design instructional strategies that better support the development of critical thinking among impulsive students, such as providing reasoning scaffolding, engaging students in reflective analysis of solution steps, and employing geometry tasks that promote carefulness, answer verification, and mathematical argumentation.

Keywords: Critical Thinking, Impulsivity, Cognitive Style, Geometry Problem

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Mathematics learning requires students to develop higher-order thinking skills, particularly critical thinking. As defined by Facione (2015), critical thinking encompasses several essential cognitive skills, including analysis, which involves identifying inferential relationships among statements or concepts; evaluation, which refers to assessing the credibility of a claim or the logical strength of an argument; and logical decision making, which entails drawing well-reasoned conclusions based on available data or information. Within the domain of geometry, critical thinking becomes especially vital. Students are required not only to engage with visual forms but also to comprehend complex conceptual relationships, such as the properties of polygons, angles, and transformations. Critical thinking enables students to understand the interrelationships among geometric figures—such as parallelism, rotation, symmetry, and transformations—as well as to distinguish between valid and invalid arguments, perform accurate deductions, and systematically evaluate problem-solving strategies.

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Furthermore, recent research in mathematics education emphasizes the importance of visual representation and spatial visualization in supporting critical thinking in geometry learning. Numerous studies have shown that students perform better on analytical tasks when geometric problems are accompanied by visual representations. Such visualizations facilitate the analysis of structural relationships, inter-element connections, and more accurate inferential reasoning. The integration of critical thinking into geometry learning goes beyond merely answering questions; rather, it sharpens students' ways of thinking by enabling them to: (1) understand and analyze conceptual relationships among geometric figures through defining, categorizing, and recognizing patterns or structures; (2) evaluate claims or conclusions by considering visual evidence or mathematical deductions before judging their validity; (3) reason logically and draw conclusions using consistent, conceptually grounded arguments; (4) utilize visual representations—such as diagrams, models, or images—to support and clarify critical thinking processes; and (5) engage in active learning, for example through Problem-Based Learning (PBL), which promotes creativity and reflective problem solving in geometry.

Geometry learning that is intentionally designed to strengthen critical thinking provides students with deeper cognitive experiences and equips them with thinking skills that are valuable across mathematics as well as in everyday life. Skills of analysis, evaluation, and logical decision making are essential when dealing with geometric structures, visual representations, and systematic problem solving. However, the effectiveness of such learning is strongly influenced by students' cognitive styles. Impulsive students tend to make decisions quickly without sufficiently exploring alternative solutions, often at the expense of accuracy—a serious weakness in geometry, which demands precision and logical reasoning (Kagan, 2018). Research has consistently shown that reflective students demonstrate stronger critical thinking abilities in mathematical problem solving than their impulsive counterparts.

A study by Widyastuti and Jusra (2022) found that male students with an impulsive cognitive style complete tasks more quickly but often overlook essential details, such as in-depth analysis and critical evaluation, which are fundamental to mathematical critical thinking. Within the context of geometry, critical thinking encompasses dimensions such as clarity, relevance, depth, logical coherence of solution steps, and significance—all of which are crucial in conceptually rich problem solving. Understanding how impulsive students think enables teachers to develop more responsive instructional strategies, for example by providing explicit prompts such as *"recheck your work before drawing conclusions"* or by structuring stages of critical thinking in a systematic manner. In this way, geometry instruction not only accommodates the fast-paced working style of impulsive students but also enhances their accuracy and logical reasoning.By recognizing students' cognitive styles, educators can also conduct more equitable assessments. Although impulsive students may complete tasks more rapidly, they are more susceptible to systematic errors; therefore, informed assessment practices should place greater emphasis on the thinking process rather than solely on the final answer.

METHODS

This study employed a descriptive qualitative research design. The research participants were ninth-grade junior high school students identified as having an impulsive cognitive style based on the results of the standard version of the Matching Familiar Figures Test (MFFT) developed by Kagan, Rosman, and Day (1964). The MFFT instrument used in this study consisted of 12 pictorial items, each comprising one target image and six comparison images, with students required to select the image identical to the stimulus. The classification of an impulsive cognitive style was determined using two primary indicators:

response latency and number of errors. Students were categorized as impulsive if they demonstrated a relatively fast response time (below the group mean) and a high number of errors (above the group mean). The MFFT has been reported to possess good reliability, with strong internal consistency and temporal stability documented in Kagan's early studies.

Based on the MFFT results, two students were identified as having an impulsive cognitive style, and one of them was designated as Subject 1 (S1). The main research instruments consisted of: (1) a geometry problem-solving test involving contextual tasks related to circles and solid geometry, and (2) semi-structured interview guidelines designed to explore students' critical thinking processes while solving the tasks. The research procedure comprised four main stages: (1) identification of students' cognitive styles using the MFFT; (2) administration of the geometry problem-solving test; (3) in-depth interviews with the research subjects; and (4) data analysis using the Miles and Huberman (2014) model, which includes data reduction, data display, and conclusion drawing. The indicators of critical thinking ability employed in this study were adapted from Ennis (2011) and included: providing simple explanations, building basic skills, making inferences, providing further explanations, and organizing strategies and tactics.

RESULTS AND DISCUSSION

The following findings indicate that both impulsive subjects exhibited the following tendencies.

Providing Simple Explanations: the students were able to understand the problem in general; however, they tended to act hastily when writing down the given information and identifying what was being asked

Figure 1 illustrates an excerpt of S1's written work in stating the known information and what was required.

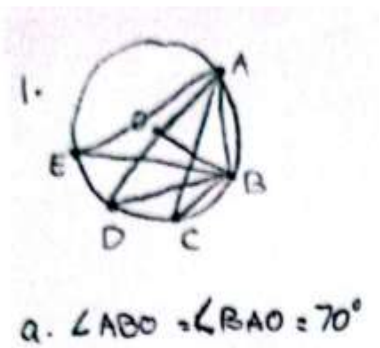


Figure 1. Student's Response in Understanding the Problem

As shown in Figure 1, during the problem-understanding stage, the student still exhibited several weaknesses in interpreting the geometric problem. S1 read and comprehended the problem quickly; however, this understanding tended to be superficial. S1 was able to instantly recognize visual elements such as points A, B, C, D, and E, as well as given information such as "∠ABO = 70°," yet failed to carefully examine the overall configuration of the figure. Reflection on how the shapes and angles were interrelated was also very limited.

Moreover, S1 demonstrated insufficient in-depth analysis of visual and conceptual relationships. Fundamental reasoning—such as recognizing that *O is the center of the circle and therefore inscribed angles have specific properties*—was often overlooked due to an impulsive tendency to focus immediately on the most salient information while ignoring important details such as symmetry, angle relationships, or the possible use of auxiliary lines. S1 also relied more on intuition or rapid guessing than on constructing a clear representation. The student tended not to produce symbolic, visual, or verbal notes regarding the observed relationships; for example, S1 did not explicitly note the relationship between radial lines and inscribed angles, resulting in answers that were formulated based solely on initial impressions. Evaluation of details and consideration of alternative interpretations were likewise very limited. At the initial stage, when assumptions such as *"Is O truly the center of the circle?"* or *"What is the relationship between AB and CD within the circle?"* should have been verified, S1 frequently failed to do so.

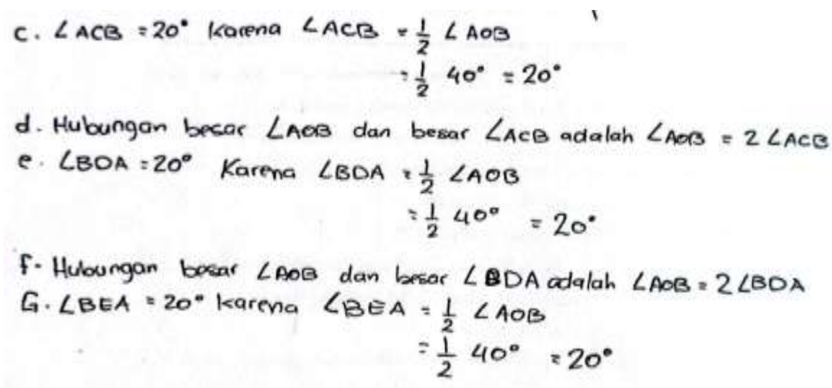
Students with an impulsive cognitive style tend to perceive and respond to problems quickly; however, they often bypass in-depth analysis and the re-examination of underlying assumptions. As a result, their understanding of geometry problems is frequently superficial and unsystematic. This finding is consistent with Rosita et al. (2021), who reported that students with an impulsive cognitive style do engage in planning, monitoring, and evaluation processes, but these stages are carried out hastily and with limited awareness of the metacognitive activities involved. Consequently, the problem-understanding phase—which should involve comprehensive analysis—is often either skipped or performed in a rushed manner.

Similarly, Hermin et al. (2023) found that impulsive students demonstrate awareness and regulation at the initial stages (understanding and planning); however, evaluation during the execution stage is generally inconsistent, and final reflection (*looking back*) tends to be weak. As a result, students' initial understanding of the problem remains at a surface level, with little revalidation of assumptions or conceptual relationships. Appulembang and Tamba (2021), in their investigation of problem-solving abilities among impulsive students, reported that one of the two impulsive subjects achieved only the unistructural level in the SOLO taxonomy, indicating a very simple and shallow level of understanding. This suggests that although impulsive students may comprehend problems quickly, the depth of conceptual integration is severely limited.

Research on numerical misconceptions further indicates that impulsive students exhibit a higher rate of misconceptions—approximately 34.17%—particularly in symbolic operations or conceptual transformations. This tendency arises because they often rush through problem-solving processes without carefully verifying each step. Identifying this pattern is crucial as a basis for designing instructional interventions that incorporate explicit elements of reflection and evaluation, such as metacognitive rubrics, scaffolded reflection prompts, or the systematic integration of "answer-checking" stages at each step of the problem-solving process.

Building Basic Skills: S1 was able to identify essential information; however, the student frequently selected incorrect formulas due to insufficient careful examination

Figure 2 illustrates an excerpt of S1's written response.



Translate:
c. ∠ACB = 20°, because ∠ACB = ½ ∠AOB
½ × 40° = 20°
d. The relationship between central angles and inscribed angles is:
∠AOB = 2∠ACB
e. ∠BOA = 20°, because ∠BOA = ½ ∠AOO
½ × 40° = 20°
f. The relationship between central angles and inscribed angles is:
∠ADB = 2∠BOA
g. ∠BCA = 20°, because ∠BCA = ½ ∠AOB
½ × 40° = 20°

Figure 2. Excerpt of S1's problem-solving work

Based on Figure 2, S1's work reflects typical impulsive behavior, characterized by rapid identification of explicit data (superficially correct), application of formulas without contextual validation (conceptually inappropriate), and the absence of cross-checking procedures (resulting in undetected and potentially cascading errors). S1 stated, *"∠ACB = 20° because ∠ACB = ½ ∠AOB."* However, S1 did not verify whether ∠AOB was indeed a central angle or whether ∠ACB was an inscribed angle; consequently, the application of the half-angle relationship may have been contextually incorrect.

S1 tended to recognize immediately visible information, such as the given angle measures (e.g., ∠ACB = 20° or the assertion that ∠ACB is half of ∠AOB), without conducting a deeper analysis of the overall relationships among the elements in the figure. While S1 captured the literal clarity of the information, the student failed to consider strategic relationships such as the location of the center point, the type of angle (central versus inscribed), and other relevant geometric properties.

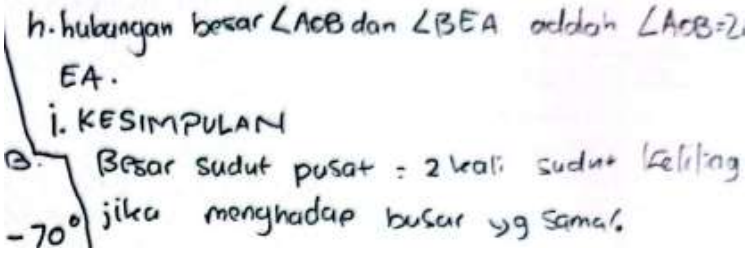
Consistent with the findings of Satriawan et al. (2018), impulsive students are often able to connect basic information with arithmetic operations but tend to overlook subsequent logical chains and answer verification. After quickly identifying angles or numerical values, S1 immediately applied what appeared to be an appropriate formula without further contextual examination—for example, using the central-angle half relationship without confirming that the angle in question was indeed a central angle, or ignoring the relationship between central and inscribed angles.

Furthermore, according to Setiani et al. (2020), impulsive students frequently commit comprehension and transformation errors due to haste, formula confusion, and lack of careful attention. After applying a formula, S1 did not revisit the solution to assess whether the chosen formula was appropriate or whether the result was reasonable. The student appeared satisfied with the immediate outcome and rarely engaged in re-reading or re-calculation, allowing errors to remain undetected.

Satriawan et al. (2018) further emphasized that impulsive students typically perform only a superficial check, without recalculating or critically reviewing their solutions.

Drawing Conclusions

Impulsive students often write down their answers immediately without rechecking the calculation process, resulting in inaccurate outcomes.



Translate:
h. The relationship between ∠ACB and ∠BEA is:
∠ACB = ∠BEA
i. CONCLUSION
The measure of a central angle is twice the measure of an inscribed angle if they subtend the same arc.

Figure 3. S1's Written Conclusion

Figure 3 shows that the impulsive student (S1) immediately drew the conclusion: "The measure of a central angle is twice the measure of an inscribed angle if they subtend the same arc." Although this statement is conceptually correct, the manner in which it was presented reflects a reasoning pattern characteristic of an impulsive cognitive style. S1 articulated the final result quickly, fluently, and concisely, without providing a deductive explanation of why the relationship holds. The student did not explicitly restate fundamental definitions (e.g., the distinction between a central angle and an inscribed angle), did not verify whether the angles in the figure satisfied the conditions of the theorem, and did not check prerequisite conditions such as whether the angles indeed subtended the same arc. In other words, S1 relied more on recall of a known rule than on a deductive process to validate the rule within the given geometric context.

This phenomenon aligns with the characteristics of an impulsive cognitive style, which include rapid responses, a strong focus on final outcomes, and a tendency to bypass evaluative steps necessary to ensure conceptual accuracy. Kartika and Muhassanah (2025) reported that impulsive students typically demonstrate the ability to capture initial information but rarely engage in monitoring the quality of their understanding. Similarly, Suningsih et al. (2023) emphasized that reflective students make extensive use of visual and symbolic representations, along with systematic rechecking, when constructing solutions, whereas impulsive students tend to prioritize immediate answers without explicitly connecting the underlying logical steps.

Within the context of geometry, this tendency has significant consequences. Geometry relies heavily on formal deductive reasoning, such as identifying the positions of points, types of angles, properties of figures, and relationships among objects before drawing conclusions. When validation processes are bypassed, students are more susceptible to misconceptions, particularly in topics that depend on strict prerequisite conditions, such as central angles, inscribed angles, and circle theorems.

This helps explain why S1 was able to produce an answer that appeared correct while demonstrating limited depth of understanding.

In addition to portraying patterns of impulsive students' thinking, the findings of this study should be interpreted in light of several methodological limitations. First, the number of participants was very small (*n* = 2), allowing for in-depth analysis but limiting the generalizability of the results. Second, the study was conducted in a single school site, meaning that instructional context, classroom culture, and local teaching practices may have influenced the findings. Third, analysis of students' thinking processes is inherently susceptible to potential researcher bias, particularly in interpreting non-verbal actions or inferring meaning from brief responses typical of impulsive students. Therefore, these findings are best understood as contextual and exploratory insights, rather than as representations of the behavior of all impulsive learners.

The practical implications highlight the importance of teacher professional development (PD) focused on strategies for supporting students with an impulsive cognitive style. Teachers need to be equipped with scaffolding approaches such as: (1) reflective prompts that guide students to revisit their solution steps, (2) explicit practice in checking prerequisite conditions and theorem requirements in geometry, (3) the use of visual reasoning checklists, and (4) simple metacognitive strategies for impulsive students, such as *"pause–think–verify"* before writing conclusions. These approaches can help impulsive students productively slow down their thinking processes, enabling deductive reasoning to occur without suppressing their spontaneity.

For future research, intervention-based PD studies are needed to examine the effectiveness of teacher training programs specifically designed to support the deductive reasoning of impulsive students. In addition, replication studies with larger samples and across different school contexts are essential to test the consistency of the identified patterns. Future research may also be extended to other geometry topics—such as triangles, parallel lines, and geometric transformations—which involve different deductive reasoning demands, in order to map how impulsivity influences thinking processes across a broader range of geometric domains.

Further Explanation

During the interview session, the participant struggled to articulate logical reasoning underlying the solution steps. The following interview excerpt was used to validate S1's problem-solving process through dialogue between the researcher (R) and S1.

R : "Could you explain how you determined the angle values in the figure?"
S1 : "That's because I saw that the angle is half of the central angle."
R : "Before applying that rule, did you check whether the angle is indeed an inscribed angle?"
S1 : "Not really. I immediately applied the formula because the figure looks like a circle."
R : "So you directly applied the formula without ensuring that the conditions were met?"
S1 : "Yes."
To ensure whether S1 verified the conditions of the formula, the researcher then probed the relationships among the given elements.
R : "Did you try to check whether the angles were the same or different?"
S1 : "No, I usually apply the formula right away once I see a circle."
The researcher then asked S1 to perform verification before applying the rule.
R : "Try to verify first before using the formula."
S1 : "I usually don't do that. I just apply it quickly.

The interview excerpts reveal a reasoning pattern that is consistent with the characteristics of an impulsive cognitive style. Throughout the dialogue, S1 repeatedly asserted answers rapidly by relying on memorized general rules regarding central and inscribed angles, without verifying the prerequisite conditions of the theorem or conducting a detailed analysis of the figure. This tendency is evident when S1 stated: *"A central angle is twice an inscribed angle if they subtend the same arc,"* and *"I saw that O is in the middle, so it must be a central angle… therefore the rule automatically applies."* These statements indicate that S1 employed an instant rule-based reasoning pattern, directly applying a recalled rule without evaluating the specific geometric context or the conditions under which the rule is valid. In geometry, the application of a theorem requires accurate identification of visual elements, such as the position of points, the type of angle, and the relevant arc involved. However, S1 demonstrated a tendency to skip this validation stage. When asked whether the arcs were the same or different, S1 responded: *"I think they are the same; they look similar, so I just used that formula right away."*

This excerpt emphasizes the low level of validation in S1's problem-solving process, particularly regarding visual accuracy and the examination of relationships among geometric objects. S1 relied on rapid perception and a sense of "visual similarity" as the basis for applying the theorem, rather than engaging in systematic analysis. This aligns with literature suggesting that impulsive students tend to focus on the most salient information while neglecting structural details that affect the accuracy of deductions. Moreover, S1 confirmed that additional checking was considered unnecessary due to strong confidence in memorized rules: *"I've memorized the formula, so there's no need to check too much, Ma'am."* This statement reflects a thinking pattern that prioritizes speed and confidence in memorization over deeper reasoning processes. In contrast, key components of critical thinking based on Ennis's indicators—such as *seeking reasons*, *evaluating assumptions*, and *validating conclusions*—were not evident in S1's responses. This phenomenon is consistent with the findings of Kartika and Muhassanah (2025), who reported that impulsive students are capable of capturing initial information but tend to lack monitoring of their understanding quality. Similarly, Suningsih et al. (2023) found that reflective students engage more frequently in representation and re-evaluation before drawing conclusions, whereas impulsive students like S1 tend to move directly toward the final answer.

The absence of step-by-step verification in S1's thinking process increases the risk of misconceptions, particularly in geometry, which requires careful identification of figure structures and formal deduction based on geometric properties. Although S1's conclusion was generally correct, the lack of thorough analysis of the diagram indicates limited depth of understanding. Dependence on memorized rules without examining the conditions that justify their application is a defining characteristic of impulsive cognitive patterns. Thus, the interview excerpts reinforce the main findings of this study that impulsive students tend to: (1) provide rapid answers without evaluation, (2) fail to check theorem prerequisites, (3) rely on rule memorization rather than deductive reasoning, and (4) omit necessary visual–conceptual validation in geometric problem solving.

S1 confessed, *"I only looked at the marked parts… I didn't have time to look at the others because I immediately focused on answering."* This statement reflects an impulsive tendency to rely primarily on immediately visible cues, without conducting an in-depth analysis of visual–conceptual relationships. Such an approach often leads students to overlook critical assumptions, for example, whether a given point truly represents the center of the circle or whether the angles indeed subtend the same arc. The interview results indicate that although S1 was able to complete the task, the answers were not always accurate due to minimal re-evaluation. Muhtarom et al. (2018) similarly reported that impulsive students, despite responding quickly, frequently produce less accurate solutions because they tend to work without sufficient caution. Likewise, other studies have concluded that although reflective and impulsive cognitive styles both pass through similar cognitive stages, impulsive learners exhibit particular limitations, especially during the final evaluation and verification phase.

Strategies and Tactics

S1 tended to rely on familiar geometric strategies, generally basic rules or solution patterns learned previously, and applied them quickly and directly. However, the lack of readiness to consider alternative strategies indicates cognitive rigidity. This is characterized by: the automatic use of a single strategy, even when it is not fully appropriate to the problem context. For example, S1 immediately applied the rule that the central angle is twice the inscribed angle without verifying whether the diagram actually satisfied the required conditions. In addition, S1 was less exploratory in problem solving, which reduced the possibility of identifying more appropriate or effective approaches when the initial strategy was inadequate. These findings are consistent with Kagan's theory (2018), which suggests that impulsive learners tend to be less careful, make decisions quickly, and rarely evaluate their results in depth. This contrasts with reflective learners, who are generally more cautious and thorough. The implication of this study is that teachers need to provide scaffolding through problem-solving activities that emphasize critical thinking steps, the use of probing questions, and the cultivation of reflective habits when reviewing answers.

CONCLUSION

Students with an impulsive cognitive style tend to act quickly and are able to identify basic information in geometric problems; however, they exhibit significant weaknesses in critical thinking. Their lack of readiness to engage in careful planning, consider alternative strategies, and conduct verification leads them to perform calculations carelessly, overlook logical checks or underlying conceptual structures, and fail to articulate strong logical arguments. This understanding highlights the need for instructional interventions by teachers, such as scaffolded prompts, reflective checklists, or critical thinking rubrics, to strengthen the accuracy and logical coherence of impulsive students' thinking. This study underscores the importance of learning approaches that take students' cognitive styles into account in order to foster the optimal development of critical thinking skills.

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