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MATHEMATICAL CONNECTION SKILLS IN PROBLEM SOLVING: THE ROLE OF COGNITIVE STYLES AMONG UPPER ELEMENTARY STUDENTS

[1]Laili Nurul Azizah, [2]Erry Hidayanto, [3]Punaji Setyosari
[1,2,3] Universitas Negeri Malang
azizahnurul705@gmail.com, erry.hidayanto.fmipa@um.ac.id, punaji.setyosari.fip@um.ac.id

ABSTRAK

This study explores elementary students' mathematical connection skills in solving problems based on their cognitive styles. A qualitative descriptive approach was employed to explain how reflective and impulsive students approach mathematical problem-solving. The research was conducted at SDN 4 Sumberbendo, Tulungagung, with 21 students initially tested using the Matching Familiar Figure Test (MFFT) to identify cognitive styles. This group selected six students (three reflective and three impulsive) as the primary subjects for detailed analysis. Data were collected through mathematical connection tests and semi-structured interviews, focusing on indicators of mathematising, representation, reasoning, communication, and strategy use. The findings reveal distinct differences between reflective and impulsive students. Reflective students demonstrated systematic and careful approaches, stronger skills in representation and reasoning, and better use of mathematical concepts such as least common multiples (LCM) and greatest common divisors (GCD). However, they often struggled to connect mathematical ideas with real-life contexts, such as percentage discounts or distribution problems. In contrast, impulsive students tended to answer quickly with less accuracy, often neglecting logical justification, although some succeeded in solving concrete problems like LCM tasks. Overall, the study highlights that cognitive styles significantly influence the quality of mathematical connections. The findings underscore the need for differentiated instructional strategies: reflective students should be supported to improve efficiency, while impulsive students require guidance to enhance accuracy and systematic reasoning.

Keywords: mathematical connection, problem-solving, cognitive style, reflective, impulsive.

INTRODUCTION

Building meaningful mathematical connections has become a significant focus in contemporary mathematics education (Stolte et al., 2020). Mathematics is not merely a collection of separate rules, formulas, or algorithms but a coherent system of interconnected concepts, structures, and representations. This system enables individuals to understand, interpret, and solve problems both within and outside the realm of mathematics (Wongupparaj & Kadosh, 2022). In the 21st century, when problem-solving, critical thinking, and knowledge transfer skills are increasingly valued, students' ability to connect mathematical ideas across topics and apply them to real-life situations has become essential to higher-order thinking skills (Cresswell & Speelman, 2020). In basic education, this competency is crucial because the foundation of students' mathematical reasoning is built in the upper grades of elementary school (Ng et al., 2014). If students fail to develop the ability to connect mathematical ideas at this stage, they are likely to experience ongoing difficulties at higher levels and face obstacles in applying mathematics to everyday life (Hardiansyah et al., 2024; Pongsakdi et al., 2020).

However, various reports from national and international assessments indicate that student performance on tasks requiring conceptual connections remains unsatisfactory. International studies such as the Programme for International Student Assessment (PISA) and Trends in International Mathematics and Science Study (TIMSS) consistently confirm that Indonesian students, as well as many students in other developing countries, often struggle with non-routine math problems that require relational understanding rather than simply memorizing procedures. (OECD, 2019). These findings indicate that many students learn mathematics as fragmented knowledge, applying rules separately without understanding the connections between concepts. As a result, when faced with new or complex problems, they often fail to transfer their previously acquired knowledge to different situations. (Strohmaier et al., 2022).

At the classroom level, this challenge is exacerbated by learning practices that emphasize procedural skills rather than conceptual understanding. Teachers often feel pressured to cover a large amount of material in a limited time, so they tend to focus more on algorithmic exercises and routine problems. (English, 2023). This pedagogy unknowingly reduces students' opportunities to engage in higher-level reasoning and experience mathematics as interconnected knowledge. (Pourdavood et al., 2020). Although procedural competence remains important, it does not prepare students to become flexible problem solvers. (Monteleone et al., 2023). What is more urgent is a balance between procedural fluency and the development of mathematical connection skills—skills that enable students to see mathematical structures holistically, connect new knowledge with prior knowledge, and apply mathematical reasoning meaningfully in various contexts. (Gilmore, 2023).

The specific issue raised in this study is the limited connection skills of upper elementary school students when solving mathematical problems. Empirical evidence from various classroom contexts shows that many students, despite being able to execute standard algorithms, experience difficulties when asked to explain their reasoning, represent mathematical relationships in various forms, or connect between mathematical domains such as arithmetic, geometry, and measurement. (Hawes & Ansari, 2020). In particular, tasks that require bridging the gap between school mathematics and everyday life often reveal significant gaps in students' ability to connect abstract concepts with concrete applications. (Pantsar, 2021). The inability to make such connections hinders success in problem-solving and reduces students' confidence and motivation in learning mathematics. (Stelzer et al., 2024).

Furthermore, students are not homogeneous. They come to class with diverse individual differences, including cognitive preferences and ways of processing information. One factor that is considered influential is cognitive style. Cognitive style refers to a person's consistent patterns of perceiving, processing, and organizing information. One of the most widely studied distinctions is between students with a field-dependent and field-independent style. Field-dependent students tend to rely on external references and have difficulty extracting relevant information from complex backgrounds, whereas field-independent students are more self-sufficient in organizing information and excel at tasks requiring detailed analysis. (Zhang & Andersson, 2023). This difference can influence students' approaches to solving mathematical problems, especially when the task requires identifying relationships and connecting concepts. (Nguyen et al., 2020). Research on the relationship between mathematical connection abilities and cognitive styles is urgent, not only in practical but also in theoretical dimensions.

Theoretically, mathematics education emphasizes understanding how individual characteristics influence mathematical thinking and problem solving. A deep understanding of the cognitive basis of connection formation can enrich theoretical models of mathematical cognition while strengthening the design of learning interventions. From a practical perspective, this research has direct implications for classroom practice. Teachers can design differentiated learning strategies that better suit student diversity by understanding how cognitive styles influence students' abilities to connect mathematically. For example, field-dependent students can be assisted with explicit scaffolding and structured opportunities to make connections. In contrast, field-independent students may thrive more through exploratory open-ended problem-solving tasks (Erfi, 2020). A systematic approach to these differences can improve the quality of mathematics learning in elementary schools.

Based on these considerations, this study aims to answer three main questions: (1) How do high-grade elementary school students' mathematical connection abilities manifest when solving problem-solving tasks? (2) Are there differences in mathematical connection abilities between students with different cognitive styles? (3) How does cognitive style influence variations in students' mathematical connection abilities? These questions reflect an effort to bridge cognitive psychology with mathematics education, highlighting descriptive patterns of student abilities and the underlying explanatory mechanisms.

In line with this, the objectives of this study are: first, to describe the level and characteristics of mathematical connection abilities demonstrated by upper elementary school students when solving mathematical problems; second, to analyze differences in mathematical connection abilities based on students' cognitive styles; third, to explore the extent to which cognitive style contributes to explaining variations in mathematical connection abilities. With these objectives, the study is expected to produce findings that are both theoretically and practically valuable. Previous studies have touched on related issues, but there are still limitations. Studies on mathematical connection abilities have been conducted more at the middle or college level, while the elementary school context has been relatively rarely explored.

Similarly, studies on cognitive styles in mathematics education often focus on general problem-solving performance rather than on the specific dimensions of connection abilities. Several studies have shown that field-independent students excel in analytical tasks compared to field-dependent students, but few discuss how these differences manifest in connecting concepts across mathematical topics. (Aggarwal et al., 2022). Furthermore, research linking cognitive styles to mathematics achievement generally highlights only the overall learning outcomes, without paying attention to the details of the process of building connections between mathematical ideas. (Kashihara & Fukaya, 2023).

This situation indicates a significant research gap. Although mathematical connection skills have been recognized in international curriculum and assessment frameworks, empirical evidence examining their interaction with differences in cognitive styles at the elementary school level remains limited. This gap represents both an opportunity and an urgent need to deepen our understanding of how cognitive characteristics influence fundamental competencies in mathematics.

The novelty of this research lies in the explicit integration of two dimensions—mathematical connection ability and cognitive style—in the context of problem solving in elementary school. By examining these two constructs simultaneously, this study offers a new perspective for understanding individual differences in mathematics learning. While previous studies tended to isolate these factors, this study highlights their interaction. Theoretically, the findings are expected to enrich the discussion on mathematical cognition by explaining the role of cognitive style in shaping connection abilities. This study practically justifies the importance of differentiated learning strategies that consider cognitive diversity in the classroom. Such an approach can improve students' mathematical understanding, support equitable learning outcomes, and strengthen the agenda for enhancing numeracy literacy.

Thus, this study focuses on a fundamental question in mathematics education: how do cognitive styles influence elementary school students' abilities to connect mathematically in problem solving? Placing this study at the intersection of mathematics education and cognitive psychology contributes to filling an essential gap in the literature while offering a new perspective for researchers and practitioners alike. Ultimately, this study's findings are expected to enrich the academic discourse on mathematical cognition and provide practical guidance for teachers who seek to support the diversity of student learning styles in the classroom.

METHODOLOGY

This study uses a descriptive qualitative approach. This approach was chosen because the study aims to describe in depth the mathematical connection abilities of students in solving problems based on reflective and impulsive cognitive styles, rather than simply measuring them in numerical form. With this approach, researchers can reveal learning phenomena in a more contextual manner, including strategies, reasons, and student experiences when facing mathematical problems. Qualitative description is appropriate because it allows for more interpretation of variations in students' cognitive styles within their mathematical thinking processes.

The research was conducted at SDN 4 Sumberbendo, Tulungagung Regency, with high school students (grades IV, V, and VI) as subjects. Based on the results of cognitive style classification through the Matching Familiar Figure Test (MFFT), 14 students representing the reflective and impulsive categories were selected. This selection aimed to obtain diverse data on mathematical thinking patterns based on cognitive styles.

The main instrument in this qualitative study was the researcher, who acted as the data collector, processor, and analyst. The supporting instrument was a semi-structured interview guide used to explore information about students' thinking processes, strategies, and difficulties in solving mathematics problems based on higher-order thinking skills (HOTS).

Table 1. Indicators of the Interview Instrument

No	Aspect Explored	Main Question	Probing / Follow-up Questions	Expected Information
1	Mathematising	How do you understand this problem?	Can you explain how you turn this story problem into a mathematical form?	Information on how students transform real-world problems into mathematical models.
2	Representation	How do you show your solution?	Can you express it in another way, for example, with a diagram, table, or symbols?	Evidence of students' ability to use multiple forms of representation.
3	Reasoning	Why did you choose this method?	Are there other reasons or strategies that could support your solution?	Insights into students' logical thinking and justification of their answers.
4	Communication	Can you explain your answer as if you were telling a friend?	How would you explain it to make it easy to understand?	Data on students' clarity, coherence, and ability to communicate mathematical ideas.

No	Aspect Explored	Main Question	Probing / Follow-up Questions	Expected Information
5	Using Tools / Strategies	What method or tool did you use to solve this problem?	Did you consider any alternative ways?	Information about students' choice of strategies or tools in solving the problem.

The research procedure was carried out in several stages. First, the researcher coordinated with the school to obtain research permission. Second, the researcher administered the MFFT test to all fourth, fifth, and sixth-grade students to identify their cognitive styles. Based on the results, 14 students were selected and divided into reflective and impulsive categories as research subjects. In the next stage, students were given HOTS-based math questions to work on individually. Afterward, semi-structured interviews were conducted with each student to explore how they built mathematical connections, their strategies, and the obstacles they faced. The interviews were recorded and transcribed for data analysis purposes.

Data analysis was conducted qualitatively following the stages outlined by Miles and Huberman, namely data reduction, data presentation, and conclusion drawing. In the data reduction stage, the interview transcripts were selected to find information relevant to mathematical connection indicators (mathematising, representation, reasoning, communication, using tools). Next, the data were presented in the form of a matrix and a descriptive narrative, making it easier for researchers to see patterns of differences between reflective and impulsive students. In the final stage, researchers drew conclusions by identifying major trends, comparing findings between subjects, and verifying data validity through triangulation (comparing interview results with students' written answers). Data analysis was conducted qualitatively following the stages outlined by Miles and Huberman, namely data reduction, data presentation, and conclusion drawing. In the data reduction stage, interview transcripts were selected to find information relevant to indicators of mathematical connections (mathematising, representation, reasoning, communication, using tools). Next, the data were presented in the form of a matrix and a descriptive narrative, making it easier for researchers to see patterns of differences between reflective and impulsive students. In the final stage, researchers drew conclusions by identifying major trends, comparing findings between subjects, and verifying data validity through triangulation (comparing interview results with students' written answers).

RESULT AND DISCUSSION

This study uses reflective and impulsive cognitive styles to describe the mathematical connection abilities of upper elementary school students at SDN 4 Sumberbendo, Tulungagung Regency. Research data were obtained through the Matching Familiar Figure Test (MFFT) to classify students' cognitive styles, HOTS-based mathematical connection tests, and semi-

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structured interviews to explore students' thinking strategies. Of the 21 students who took the MFFT test, 14 were selected based on their reflective and impulsive categories, and six subjects (three reflective and three impulsive) were then chosen for in-depth analysis. The research results were presented as focused on problem-solving patterns, thinking strategies, and the ability to connect mathematical concepts with real-life contexts. The analysis was conducted based on mathematical connection indicators: mathematising, representation, reasoning, communication, and the use of tools/strategies.

Mathematical Connections of Reflective Students

MBK showed a tendency toward reflective thinking by working on problems carefully and meticulously, even though it took relatively longer. In the chair arrangement problem, MBK was able to describe the seating pattern as a visual representation, but was less accurate in applying the concept of multiplication to calculate the total number of chairs. This pattern shows that he can visualize information but has not yet fully connected it to basic arithmetic operations.

In the question about Bima's year of birth, MBK successfully connected the information with the concept of simple addition through a trial-and-error strategy, ultimately producing the correct answer. This shows that reflective students, although slow, still take systematic steps to find the final answer. However, in the question about the police number, MBK failed to meet the question criteria because they did not correctly relate the digit addition operation to the division by 5, resulting in an incorrect answer.

In the question about lights turning on together, MBK showed a strong understanding of connecting the concept of GCD with the idea of time units. He was able to identify multiples of 10, 15, and 20 to find 60, then connect it to the starting time to find the time 10:10. In the GCF question, MBK also succeeded in using prime factorization, although only up to the number of packages, not yet to the context of dividing the gifts. In the discount question, he made a mistake by adding only the 20% + 20% discounts without understanding the concept of discount composition. These findings show that MBK has a strong tendency for mathematical thinking regarding representation and strategy use, but is still limited in contextual application.

Subject NFRN

NFRN showed relatively stable performance with a more systematic strategy than MBK. He accurately described the seating pattern in the chair question and used multiplication to calculate the number of chairs, so his answer was correct. In the birth year question, he used a systematic trial-and-error approach until he found the correct answer. However, in the license

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plate number question, although he could relate the sum of the digits to divisibility, he did not choose the most significant number as instructed.

On the light question, NFRN demonstrated good mathematical skills by calculating multiples of 10, 15, and 20, then relating them to time units. The interview results showed that he could explain the relationship between concepts clearly. However, on the GCF question, he mistakenly linked the idea of prime factorization to the context of gift packages. He only divided the most significant number of items by the smallest, so the result was incorrect. In the discount problem, he also assumed that discounts could be added directly without understanding the concept of percentages. These findings indicate that NFRN is quite strong in connecting concepts, but weak in connecting them to real-life contexts.

Subject RRES

RRES showed a reflective character with careful but sometimes incomplete work. In the chair problem, he drew the seating pattern correctly, but miscalculated the number of chairs because he did not count the corner section. He found the correct answer in the birth year problem by using addition and checking ages. In the license plate number problem, he used the logic of digit addition and division, but failed to choose the most significant number. In the light bulb question, RRES was able to calculate the GCD with prime factorization but incorrectly linked it to time, resulting in an inaccurate answer. On the GCD question, he used the factor tree correctly, but did not connect it to the context of the number of items in the package. On the discount question, his answer was completely wrong because he only added the number of kilograms to the discount without any mathematical basis. Thus, RRES showed strength in representation and calculation, but weakness in connecting to everyday contexts.

Mathematical Connections of Impulsive Students

SAS Subject

SAS exhibits dominant impulsive traits. He only drew part of the information in the chair question, resulting in an incorrect answer. In the birth year question, he managed to find the correct answer but used a trial-and-error strategy without logical reasoning. In the license plate number question, he chose numbers that met the divisibility criteria but failed to determine the most significant number. Interestingly, on the light bulb question, SAS performed best. He calculated multiples of 10, 15, and 20 until he found 60, then connected it to the initial time of 09:10 to become 10:10. This shows that even though he is impulsive, SAS can solve problems correctly when they are concrete enough. On the GCF problem, he failed because he did not use the concept of prime factorization. On the discount problem, he again added percentages without understanding the concept. This pattern confirms that impulsivity produces quick but inconsistent answers.

Subject MAFR

MAFR tends to answer partially. Regarding the seating problem, he drew a seating pattern, but it was incorrect when calculating the total number of seats. On the birth year question, he used a simple subtraction strategy (2008 – 6 = 2002), but his answer was wrong. He mathematically chose the correct license plate number, but did not follow the instructions to select the most significant number. On the light question, he calculated the multiples correctly but misinterpreted the result as a unit of time (13:00, not 10:10). On the GCF question, he did not use the concept of factorization. Instead, he added up the prize items, resulting in an incorrect answer. On the discount question, he copied the 20% number from the question without doing any calculations. This pattern shows that impulsive students can sometimes find strategies, but they are inconsistent and do not perform logical validation.

Subject MHA

MHA showed the strongest impulsive pattern. He drew the pattern correctly in the chair question, but miscalculated the number of chairs. He found the correct answer in the birth year question through trial and error. In the license plate number question, he chose numbers based on divisibility, but failed to meet the requirement for the most significant number. In the light question, he answered randomly without using the concept of LCM. In the GCF question, he responded randomly by adding all the items and then dividing them without any mathematical basis. On the discount question, he was wrong because he assumed that the number of kilograms was equal to the discount percentage. This pattern shows the severe weakness of impulsive students in mathematical reasoning consistency.

In general, reflective students excel in representation, reasoning, and strategy. They can connect mathematical concepts such as GCD and LCM, although they are unsuccessful in real-life contexts. In contrast, impulsive students tend to answer quickly, sometimes correctly, on concrete problems, but are weak in logical consistency and connection to context. These findings reinforce the idea that cognitive style plays a vital role in the quality of mathematical connection skills. Reflective students are more thorough and systematic but slow, while impulsive students are faster but less accurate.

DISCUSSION

The results of this study are consistent with the cognitive style theory proposed by Wisenöcker et al. (, which states that reflective students tend to be slow but more thorough, while impulsive students are fast but less accurate. This study clearly reflects that reflective students, like NFRN, can correctly connect the KPK with the unit of time, whereas impulsive students, like MHA, tend to answer randomly. (Deslis & Desli, 2023) emphasizes the importance of mathematical connection skills as one aspect of mathematical literacy. The findings of this study show that reflective students more often fulfill mathematical connection indicators (representation, reasoning, mathematization) even though they cannot always relate them to real contexts. Conversely, impulsive students have limitations in almost all indicators except for concrete questions.

These results align with (Tan et al., 2023) Research has found that cognitive style significantly impacts mathematics learning achievement. This study also reinforces (Hardiansyah et al., 2022) It is found that students who do not explore mathematics daily tend to fail to build contextual connections.

However, there is an interesting difference: although impulsive students are usually weak, students like SAS can answer the KPK questions correctly, showing that an impulsive style does not always mean total failure, but rather requires certain conditions of the questions. This study has several limitations that need to be noted to interpret the findings more proportionally. First, the number of research subjects was relatively limited, with only six students selected purposively from the reflective and impulsive categories.

This condition allows for in-depth exploration of the thinking process, but limits the generalization of findings to a broader population. Second, the research instruments, namely mathematical connection tests and semi-structured interviews, focused on specific material (numbers, GCF, LCM, and percentages), so the study results do not fully represent the entire domain of mathematics in elementary school. Third, qualitative analysis is highly dependent on the researcher's interpretation. Even though triangulation with students' written answers was carried out, the potential for subjectivity bias remains. Fourth, this study was conducted in one elementary school in Tulungagung Regency, where the social, cultural, and curricular contexts may differ from those of other schools. Therefore, caution is needed in generalizing the results to a broader educational context. These limitations also open up opportunities for further research with a larger subject scope, more varied instruments, and different school contexts, thereby making the understanding of the relationship between students' cognitive styles and mathematical connections more comprehensive.

For teachers, these findings imply that mathematics learning should consider students' cognitive styles. Teachers must provide time challenges for reflective students to be more efficient without sacrificing accuracy. For impulsive students, teachers must train systematic thinking skills through scaffolding, reflection, and group discussions. Theoretically, this study expands the understanding of the interaction between cognitive styles and mathematical connections. Previous research has focused more on general academic achievement, while this study emphasizes the dimensions of conceptual and contextual connections. Thus, this study makes a new contribution to the literature on mathematics education.

Overall, the results of this study show significant differences between reflective and impulsive students in terms of mathematical connection abilities. Reflective students excel in representation, reasoning, and strategy, while impulsive students excel in speed but are prone to logical errors. Both face challenges connecting mathematical concepts to real-life contexts, especially in discount and GCF problems. The practical implication is that teachers must develop differentiated learning strategies according to students' cognitive styles. The theoretical implication is that this study enriches our understanding of how cognitive styles play a role in mathematical connections, especially at the elementary school level. Thus, this study provides an essential basis for developing curricula and pedagogical practices more responsive to student diversity.

CONCLUSION

This study reveals that cognitive style plays a significant role in shaping the mathematical connection abilities of upper elementary school students. Students with a reflective cognitive style tend to solve problems more carefully, systematically, and thoroughly. They can build connections between mathematical concepts, such as GCD and LCM, and represent information more accurately. However, despite being relatively accurate, reflective students still face challenges connecting mathematical concepts to real-life contexts, such as in questions about discounts or dividing gift packages. Conversely, students with an impulsive cognitive style respond quickly to questions but tend to be less thorough and often produce inconsistent answers. In some cases, such as LCM problems, impulsive students can provide correct answers, but in most other problems, they fail to establish logical or contextual connections. In general, the study's results confirm that differences in cognitive style have direct implications for the quality and pattern of students' mathematical connection abilities. Reflective students excel in accuracy and representation, while impulsive students are faster but prone to errors.

Both groups show weaknesses in connecting mathematical concepts to everyday problems, thus requiring more contextual learning interventions. These findings theoretically enrich the understanding of the relationship between cognitive style and mathematical connections, while providing practical implications for teachers to apply differentiated learning strategies tailored to students' cognitive characteristics.

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