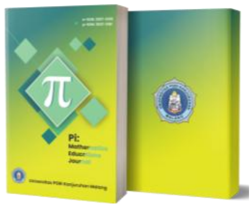
Pi: Mathematics Education Journal
e-ISSN: 2597-6915 p-ISSN: 2597-5161
Volume 9, No. 1, 2026 | Hal. 39 – 50



Students' Metacognitive Processes in Mathematical Problem Solving Viewed from VARK Learning Styles

Aning Wida Yanti[a,1,*], Rahma Alvira[a,2]
[a]Mathematics Education of State Islamic University of Sunan Ampel Surabaya, Indonesia
[1]aning.widayanti@uinsa.ac.id
[2]rahmaalv0810@ gmail.com
[*]Corresponding Author

ARTICLE HISTORY
Received:
January 11, 2026

Revised:
March 10, 2026

Published:
April 30, 2026

Keywords:
Metacognitive processes
Problem Solving
VARK Learning Styles

ABSTRACT
Metacognition plays a crucial role in enhancing students' problem-solving abilities through the processes of planning, monitoring, and evaluation, enabling more systematic and effective thinking. In addition, students' learning styles influence how metacognitive processes are applied in solving mathematical problems. Understanding these processes allows teachers to design instructional strategies that align with students' characteristics. This study aims to describe students' metacognitive processes in solving mathematical problems based on VARK learning styles. A qualitative case study approach was employed involving eight tenth-grade students of MAN 2 Kota Kediri, with two students representing each learning style identified through the VARK questionnaire. Data were collected using problem-solving tests and semi-structured interviews, then analyzed through data condensation, data display, and conclusion drawing, with source triangulation ensuring validity. The findings reveal that visual and read/write learners demonstrate more consistent performance in understanding problems and applying strategies, although evaluation is sometimes incomplete. Auditory and kinesthetic learners tend to rely on previously learned strategies but show less consistency in monitoring and evaluating their solutions. All students exhibit confidence in their approaches based on prior experiences. Further research is recommended to explore metacognitive processes using more diverse problem types.

How to Cite: Yanti, A. W. & Alvira, R. (2026). Students' Metacognitive Processes in Mathematical Problem Solving Viewed from VARK Learning Styles. *Pi: Mathematics Education Journal, 9*(1), 39-50. https://doi.org/10.21067/pmej.v9i1.13716

1. Introduction

Problem solving is one of the main objectives of mathematics learning, because through this activity students are not only required to obtain final answers, but also to understand the thinking processes used to reach solutions. According to Piaget, at the formal operational stage, which generally begins around the age of 12, students possess the ability to think symbolically and logically, enabling them to organize and control their thinking processes in solving problems. This ability indicates a close relationship between cognitive development and the way students manage their thinking when facing mathematical problems. One important aspect that influences students' cognitive development in learning is metacognition. Metacognition plays a significant role in helping students control their thinking processes during learning [1]-[3] defines metacognition as a form of higher-order thinking related to awareness and control over the cognitive processes involved in learning. In other words, metacognition allows students to be aware of what they know, how they learn, and which strategies are most effective for solving a task.

Metacognition consists of two main components, namely metacognitive knowledge and metacognitive experiences. Metacognitive knowledge relates to an individual's understanding of strategies, tasks, and effective learning conditions, including the ability to plan, monitor, and reflect on the learning process [4]. Meanwhile, metacognitive experiences are associated with awareness and the application of metacognitive strategies during ongoing thinking processes. Metacognitive strategies themselves are a set of behaviors that function to regulate cognitive processes so that learning goals can be achieved, such as planning solution steps, monitoring progress, checking the suitability of strategies, and evaluating results. In line with this view, [4] state that metacognition includes three main components: awareness, evaluation, and regulation. Awareness refers to students' consciousness of facts, information, and task demands. Evaluation relates to students' ability to assess their understanding and problem-solving processes. Regulation refers to students' ability to control and adjust the strategies used, including providing reasons for selecting certain techniques in solving problems.

In the context of mathematics learning, metacognition is closely related to problem-solving activities. Mathematical problem solving can be classified into routine and non-routine problems. Routine problems can generally be solved using procedures that have been previously learned, whereas non-routine problems require students to think more deeply and flexibly because they cannot be solved directly using standard algorithms [5]. In such situations, the role of metacognition becomes crucial, as students need to plan strategies, monitor processes, and evaluate the solutions obtained. Polya proposed four main steps in problem solving, namely understanding the problem, devising a plan, carrying out the plan, and looking back at the solution [6][7]. These steps are consistent with the metacognitive indicators, namely planning, monitoring, and evaluation [8][9]. In the planning stage, students determine goals and strategies to be used. The monitoring stage involves supervising the ongoing problem-solving process, while the evaluation stage relates to assessing results and the effectiveness of the strategies employed.

In addition to metacognition, another factor that influences students' success in mathematical problem solving is learning style. Learning style determines how students absorb information and process new knowledge [10]. One of the learning style models widely applied in educational contexts is the VARK model (Visual, Auditory, Read/Write, and Kinesthetic), which categorizes students' learning preferences into four main types [11]. Students with visual learning styles tend to understand information more easily through images, diagrams, and visual displays. Auditory learners learn more effectively through verbal explanations, discussions, and listening. Students with read/write learning styles are more comfortable learning through texts, notes, and writing activities, while kinesthetic learners prefer learning that involves physical activity and hands-on practice [12]. These differences in learning styles are assumed to influence how students plan, monitor, and evaluate their thinking processes when solving mathematical problems.

Various previous studies have examined the relationship between metacognition and mathematical problem solving. Found that students are able to solve mathematical problems effectively through the use of high-level metacognition [13][14]. According to [2], metacognition has a very close relationship with problem solving because it helps individuals plan, monitor, and evaluate their thinking processes when solving problems. In mathematics learning in particular, metacognitive ability enables students to become more aware of the strategies they use, making the problem-solving process more effective.

Problem solving is the process of finding a solution to a situation in which the method of resolution is not immediately known. The steps proposed by George Pólya include understanding the problem, devising a plan, carrying out the plan, and reviewing the result. Metacognition plays a role at each stage of the problem-solving process. The relationship between the two lies in the role of metacognition in helping individuals understand the problem, select appropriate solution strategies, monitor the problem-solving process, and evaluate the results. Each student has a different learning style. Differences in learning styles (such as visual, auditory, and kinesthetic) can influence how students receive information, process knowledge, and apply strategies when solving mathematical problems. [15] showed that students with certain learning styles experience difficulties in different metacognitive components, both in metacognitive knowledge and metacognitive experiences. [16] reported that students' mathematical problem-solving abilities are influenced by metacognitive knowledge and visual learning approaches. Students use their learning styles as a basis for determining metacognitive strategies when solving mathematical problems [17][18].

Nevertheless, most of these studies focus more on the relationship between metacognition and problem-solving outcomes or examine specific learning styles separately. Research that deeply describes students' metacognitive processes based on all four VARK learning style categories, particularly in the context of senior high school or madrasah aliyah students, remains relatively limited. In addition, studies that explicitly connect Polya's problem-solving stages with Schraw's metacognitive indicators within the VARK learning style framework are still scarce. Based on this research gap, this study aims to describe students' metacognitive processes in mathematical problem solving viewed from the VARK learning styles. This study is expected to provide theoretical contributions by enriching the literature on metacognition and learning styles, as well as practical contributions for teachers in designing learning activities that are more adaptive to students' learning characteristics and in optimally developing students' metacognitive skills. The purpose of this study is to describe the metacognitive processes of students with visual, auditory, read/write, and kinesthetic learning styles in solving mathematical problems.

2. Methods

This study employed a qualitative case study design to obtain an in-depth understanding of students' metacognitive processes in solving mathematical problems based on differences in learning styles. The case study approach was chosen because it allows for a detailed exploration of individual thinking processes within a specific context. A qualitative approach was considered appropriate as the study emphasizes meaning construction, cognitive strategies, and students' experiences during problem solving rather than numerical generalization [19][20]. The research was conducted at MAN 2 Kediri City during the even semester of the 2023/2024 academic year and involved tenth-grade students. The selection of the research site was based on the relevance of the institutional context to the research objectives, as well as the researcher's accessibility to participants and data sources. This setting provided a suitable environment for examining students' metacognitive behavior in mathematics learning.

The research subjects were selected from tenth-grade students using purposive sampling, which involves selecting participants based on specific criteria relevant to the research focus [21]. The primary criterion for subject selection was students' learning style classification as determined by the VARK learning style test. Learning styles were identified using a VARK questionnaire developed by Fleming and Mills and adapted from [22]. The VARK learning style test instrument meets the criteria of validity and reliability. The questionnaire was administered online via Google Form to 32 students from class X-1. The VARK learning style instrument consisted of 32 multiple-choice items, each with four response options: always, often, sometimes, and never. Students were instructed to choose one response for each item. The results of the questionnaire were analyzed to classify students into four learning style categories: visual, auditory, read/write, and kinesthetic.

The process of selecting research subjects began with determining the class to be studied, followed by administering the VARK learning style test to all students in the selected class. After the learning style classification was completed, two students with the highest scores were selected from each learning style category. In addition to the questionnaire results, recommendations from the mathematics teacher were considered, particularly regarding students' academic abilities and learning characteristics. Based on these criteria, eight students were selected as research subjects, consisting of two students from each learning style category.

Based on the suggestions and recommendations from the mathematics teacher regarding students' learning styles, eight research subjects were selected. These consisted of two subjects with a visual learning style (S1 and S2), two subjects with an auditory learning style (S3 and S4), two subjects with a read/write learning style (S5 and S6), and two subjects with a kinesthetic learning style (S7 and S8). The selected research subjects were subsequently assigned codes to maintain the confidentiality of their identities and to facilitate data analysis. The list of research subjects is presented in Table 1.

Table 1. Research Subjects

No	Name	Type of Learning Style	Subject Code	No	Name	Type of Learning Style	Subject Code
1.	MRIA	Visual	S_1	5.	ALH	Read/Write	S_5
2.	MIH	Visual	S_2	6.	APNR	Read/Write	S_6
3.	ANA	Auditory	S_3	7.	NAM	Kinesthetic	S_7
4.	WPSA	Auditory	S_4	8.	MHP	Kinesthetic	S_8

Data collection was conducted using two main techniques: a mathematical problem-solving test and in-depth interviews. The problem-solving questions are presented in the discussion section. The problem-solving test was designed to capture students' metacognitive processes in written form, while the interviews were used to confirm, deepen, and clarify the findings obtained from the test results. The indicators of the metacognitive process commonly used in this study include planning, monitoring, and evaluation indicators [23]. The research instruments included a problem-solving test sheet and a semi-structured interview guide. Instrument validation was carried out by three validators, consisting of one lecturer from the Mathematics Education Study Program at UIN Sunan Ampel Surabaya and two mathematics teachers from MAN 2 Kediri City. This validation process aimed to ensure clarity of language, appropriateness of question construction, and relevance of content to the research objectives [24]. Data validity was ensured through data source triangulation by comparing and cross-checking information obtained from test results and interviews to enhance credibility and consistency [19][23]. Data analysis was conducted concurrently with data collection and followed the model proposed by Miles, Huberman, and Saldana, which consists of data condensation, data display, and conclusion drawing and verification [25].

3. Result and Discussion

The data in this study were obtained from the results of a mathematical problem-solving test and in-depth interviews conducted with eight research subjects. The subjects consisted of two students for each VARK learning style category. The algebraic problem-solving test was used to reveal students' metacognitive processes, which are subsequently described as follows.

1. Ahmad diminta oleh ayahnya pergi ke pasar untuk membeli buah di dua toko yang berbeda. Pertama, Ahmad pergi ke Toko Buah Segar membeli 2 kg jeruk dan 3 kg apel dengan harga total Rp82.000,00. Kemudian Ahmad melanjutkan perjalanannya ke Toko Buah Ceria, dimana ia membeli 3 kg jeruk dan 2 kg apel dengan harga total Rp72.000,00. Harga buah jeruk di Toko Buah Ceria lebih mahal Rp1.000,00 daripada Toko Buah Segar dan harga buah apel di Toko Buah Ceria lebih murah Rp2.000,00 daripada Toko Buah Segar. Di hari lain, Ahmad ingin membeli 5 kg jeruk dan 4 kg apel, ke toko mana sebaiknya Ahmad pergi? Jelaskan alasannya!
2. Bu Rina, Bu Anita, dan Bu Ira pergi ke butik penjualan batik untuk membeli batik khas Yogyakarta. Bu Rina membeli dua potong kain batik Kawung dan tiga potong kain batik Parang seharga Rp1.680.000,00. Bu Anita membeli 1 potong kain batik Kawung dan 2 potong kain batik Parang seharga Rp980.000,00. Kemudian Bu Ira juga akan membeli batik di butik yang sama. Bu Ira memiliki uang Rp3.500.000,00 untuk membeli 10 potong batik tanpa pengembalian uang. Menurut Bu Ira uang yang dimilikinya cukup untuk membeli batik dengan harapan pembelian minimal 4 potong kain batik Kawung dan 4 potong kain batik Parang. Namun menurut Bu Rina, uang Bu Ira tidak cukup untuk membeli 10 potong kain batik sedangkan menurut Bu Anita tetap bisa membeli tergantung banyaknya jenis batik mana yang akan dibeli Bu Ira dengan syarat minimal. Siapakah yang mengatakan benar? Mengapa? Berikan Alasanmu!

The results of the mathematical problem-solving test and interviews with subjects who have visual (V), auditory (A), read/write (R), and kinesthetic (K) learning styles are analyzed and described in the following section.

Table 2. Metacognitive Process Data of Subjects in Mathematical Problem Solving

Metacognitive Stage	**Problem-Solving Stage**	**Indicators of Metacognitive Processes**	**Subject**							
			Visual		**Auditory**		**Read/Write**		**Kinesthetic**	
			S_1	**S_2**	**S_3**	**S_4**	**S_5**	**S_6**	**S_7**	**S_8**
Planning	Understanding the Problem	a. The student can identify the problem presented in the question	✓	✓	✓	✓	✓	✓	×	✓
		b. The student can write down the known information and what is asked in the question	✓	✓	×	✓	✓	✓	✓	✓
	Formulating a Plan	a. The student can organize the steps used to solve the problem	✓	✓	✓	✓	✓	✓	✓	✓
		b. The student can consider the method/strategy used when understanding the problem	✓	✓	✓	✓	✓	✓	✓	✓
		c. The student can consider that the chosen method/strategy will successfully solve the problem	✓	✓	✓	✓	✓	✓	✓	✓
Monitoring	Implementing the Plan	a. The student can solve the given problem in a systematic manner	✓	✓	×	✓	✓	✓	×	✓
		b. The student monitors the progress of the work to ensure that the known	✓	✓	×	✓	✓	✓	✓	✓

		information and what is asked are appropriate								
		c. The student checks the suitability of the method/strategy used to solve the problem	✗	✗	✗	✓	✓	✓	✓	✓
		d. The student checks the calculations step by step during the solution process	✗	✓	✗	✓	✓	✓	✓	✓
Evaluation	Reviewing	a. The student reviews all complete steps to ensure the correctness of the answer	✗	✓	✗	✓	✗	✓	✗	✓
		b. The student identifies errors in the completed solution	✗	✓	✗	✓	✓	✓	✓	✓
		c. The student can consider alternative methods/strategies to solve the problem	✓	✓	✓	✓	✓	✗	✓	✓

3.1 Students' Metacognitive Processes in Mathematical Problem Solving Viewed from the Visual Learning Style

Based on Table 2, subjects S_1 and S_2 demonstrated good performance at the planning stage. Both subjects were able to understand the problem, identify the given and the required information, and formulate solution steps systematically. In addition, S_1 and S_2 were able to consider the strategies used and were confident that these strategies could solve the problem. At the planning stage, visual learners were able to comprehend the problem and write down the known and required information to facilitate understanding of lengthy word problems. They were also able to design solution steps and select elimination, substitution, or a combination of both strategies based on considerations of efficiency and suitability to the problem. These strategies were chosen because they were considered faster and had been previously learned, leading the students to believe that they would produce correct solutions.

At the monitoring stage, both subjects were able to implement the solution plan in a systematic manner and monitor the consistency between the given and required information in the problem. However, neither S_1 nor S_2 checked the appropriateness of the strategies used during the solution process. A difference was observed in the checking of calculations, where only subject S_2 performed step-by-step verification of calculations, while subject S_1 did not. This finding is consistent with the interview results of subject S_1, who stated that rechecking was not always conducted due to time constraints. At this stage, visual learners were able to solve the problems sequentially and monitor the progress of their work by re-examining the given and required information. Nevertheless, they did not consistently check the suitability of the strategies used and did not always perform detailed calculation checks, except when confusion arose or the solution process was interrupted.

At the evaluation stage, differences in metacognitive ability between the two subjects became more evident. Subject S_2 was able to review all solution steps, identify errors, and consider alternative strategies. In contrast, subject S_1 did not conduct a thorough review and did not investigate possible errors in the solution. Despite this, subject S_1 was still able to consider alternative strategies for solving the problem. This is supported by S_1's statement that in mathematics there is more than one way to solve a problem and that any potential errors are more likely due to miscalculations rather than the chosen strategy. At the evaluation stage, visual learners exhibited inconsistency in reviewing their work and identifying errors. Some students did not conduct comprehensive evaluations due to time limitations and confidence that their answers were logically correct. Nevertheless, the students remained aware of alternative strategies and believed that the strategies used were appropriate based on prior learning experiences. This finding differs from the results reported by [17], who found that visual learners tend to recheck their work and recognize errors. This discrepancy is presumed to be influenced by factors such as conceptual understanding, learning experience, and time management.

Overall, in the metacognitive knowledge component, students with a visual learning style were able to understand the problem, plan strategies, and carry out solutions systematically, although their monitoring and evaluation were not yet optimal. In the metacognitive experience component, students demonstrated confidence in the strategies used, awareness of alternative solution methods, and reflection based on previous learning experiences.

3.2 Students' Metacognitive Processes in Mathematical Problem Solving Viewed from the Auditory Learning Style

Based on Table 2, both subjects S_3 and S_4 were able to identify the problems presented in the questions and formulate solution steps. However, clear differences emerged in the subsequent stages. Subject S_4 was able to write down the given and required information in the problem, whereas subject S_3 did not. This indicates that although both subjects understood the problem, they differed in how they expressed their understanding.

At the planning stage, both S_3 and S_4 were able to design solution steps and consider the strategies to be used, namely elimination and substitution methods. Both subjects also believed that the selected strategies could solve the problem. This confidence was supported by their statements indicating that the strategies had been taught previously and were considered time efficient. However, subject S_3 did not write down the given and required information because it was considered unnecessary and time-consuming. In contrast, subject S_4 wrote down this information to facilitate understanding and control the solution process.

At the monitoring stage, the differences between the two subjects became more apparent. Subject S_4 was able to solve the problem sequentially, monitor the appropriateness of the information used, check the suitability of the strategy, and perform step-by-step calculation checks. This was evident from the written work and supported by interview statements, such as when the subject mentioned "reviewing the steps and quickly recalculating to avoid mistakes." Conversely, subject S_3 did not solve the problem sequentially, did not recheck the information used, did not examine the suitability of the strategy, and did not perform step-by-step calculation checks. Subject S_3 tended to proceed directly with the solution without exercising control over the ongoing process.

At the evaluation stage, only subject S_4 demonstrated the ability to review all solution steps and identify potential errors. Subject S_4 stated that rechecking was necessary to ensure that the answer was correct and free from calculation errors. Meanwhile, subject S_3 did not review the entire solution and did not attempt to identify possible errors. Subject S_3 believed that rechecking could cause confusion and introduce new mistakes and therefore preferred to focus on the initial solution process. Nevertheless, both subjects S_3 and S_4 were able to consider alternative strategies for solving the problem, such as using elimination, substitution, or a combination of both.

Overall, the metacognitive processes of students with an auditory learning style showed considerable variation among subjects. At the planning stage, students were able to understand the problem and devise strategies, although they did not always write down the given and required information. At the monitoring stage, some students were unable to optimally control the solution process, particularly in checking steps and calculations. At the evaluation stage, some students did not review their solutions or search for errors, yet they remained aware of alternative solution strategies. These findings are consistent with [18], who reported that students with an auditory learning style tend not to conduct thorough rechecking of their completed solutions. In terms of metacognitive knowledge, auditory learners were able to understand the problem and apply solution strategies but did not consistently engage in systematic monitoring and evaluation. In the metacognitive experience component, students expressed confidence that the strategies used were effective because they had been learned previously, recognized the existence of alternative strategies, and believed that the chosen approach was appropriate and correct.

3.3 Students' Metacognitive Processes in Mathematical Problem Solving Viewed from the Read/Write Learning Style

Based on Table 2, subjects S_5 and S_6 demonstrate good ability at the planning stage in mathematical problem solving. Both subjects can identify the problems presented and write down the known and asked information. This finding is consistent with Flavell's view that metacognitive knowledge includes an individual's understanding of the task and relevant information in the problem-solving process [6][26].

At the stage of formulating a plan, subjects S_5 and S_6 can arrange solution steps systematically and consider the strategies to be used. Both subjects also believe that the chosen strategies can solve the problem effectively. The strategies used are a combination of elimination and substitution methods, which are considered easy to understand and effective for finding solutions. This indicates well-developed planning activity, as stated by Schraw that the planning stage involves determining strategies and predicting their likelihood of success [3].

At the monitoring stage, subjects S_5 and S_6 can carry out the solution plan sequentially. Both subjects monitor the progress of their work by rechecking the consistency between known and required information, evaluating the suitability of the strategies used, and checking calculations at each stage of the solution. These activities reflect good monitoring ability, namely the ability to oversee one's thinking process and detect potential errors during problem solving [27].

Differences between the two subjects appear at the evaluation stage. Subject S_6 rechecks all solution steps to ensure the correctness of the answer, whereas subject S_5 does not conduct a comprehensive review. Nevertheless, both subjects attempt to identify errors in their completed solutions. In considering alternative strategies, only subject S_5 recognizes the possibility of other ways to solve the problem, while subject S_6 does not consider alternative strategies. These findings indicate variation in evaluative ability among subjects, which is an important component of metacognitive regulation [27].

Overall, the metacognitive processes of students with a Read/Write (R) learning style in mathematical problem-solving show relatively strong characteristics at the planning and monitoring stages. Students can understand the problem, write down information in detail, organize solution steps, and check the process and calculations. However, at the evaluation stage, limitations are still found, particularly in conducting comprehensive reviews and considering alternative solution strategies. From the perspective of metacognitive knowledge components, students with a Read/Write (R) learning style understand the task and problem information and can apply strategies and solution steps to obtain answers. Students also monitor the information, strategies, and calculations used. However, not all students conduct a thorough evaluation of the results.

In terms of metacognitive experience components, students show confidence in the strategies used and recognize the possibility of alternative solutions (particularly subject S_5). This confidence arises from previous experience in using the same strategies. These findings are consistent with Livingston's statement that metacognitive experience is related to individuals' awareness of the effectiveness of strategies used during the thinking process [3].

3.4 Students' Metacognitive Processes in Mathematical Problem Solving Viewed from the Kinesthetic Learning Style

Based on Table 2, differences in metacognitive processes are identified between subjects S_7 and S_8, both of whom exhibit a kinesthetic (K) learning style. At the planning stage, subject S_7 has not yet demonstrated the ability to clearly identify the core problem presented in the question, whereas subject S_8 is able to recognize and understand the problem effectively. Nevertheless, both subjects can write down the known information and determining what is required to be solved. In addition, S_7 and S_8 can organize solution steps, select appropriate strategies, and express confidence that the chosen strategies can be used to solve the given mathematical problem. These findings suggest that although initial problem comprehension differs, both kinesthetic learners still possess the capacity to plan problem-solving strategies in a structured manner.

At the monitoring stage, subject S_8 can carry out the problem-solving process in a sequential and coherent manner according to the previously prepared plan. In contrast, subject S_7 experiences difficulties in maintaining a consistent sequence of solution steps. Despite this difference, both subjects demonstrate the ability to monitor their problem-solving processes by rechecking the consistency between the known and required information, evaluating the appropriateness of the strategies used, and verifying calculations at each stage. This indicates that kinesthetic learners attempt to regulate their cognitive processes during problem solving, even though the execution of solution steps may not always be systematic.

At the evaluation stage, subject S_8 performs a comprehensive review of all solution steps to ensure the correctness of the final answer. Subject S_7, however, does not conduct a complete review of the entire solution process, although efforts are still made to identify possible errors in the obtained answer. Both subjects are also able to consider alternative strategies that could be applied to solve the same problem. These findings indicate that the evaluative abilities of kinesthetic learners are still developing and tend to be partial rather than comprehensive.

Overall, the results show that at the planning stage, students with a kinesthetic learning style are generally able to record known and required information and design solution steps and strategies, although not all students fully understand the problem at the outset. This finding is consistent with the study of [17], which reported that kinesthetic learners tend to focus on recording problem information as a foundation for solving tasks, even when their conceptual understanding is not optimal. The strategies employed by the students in this study mainly involve combinations of elimination and substitution methods, which are perceived as easier and more familiar due to prior learning experiences, thereby increasing students' confidence in their use. At the monitoring stage, kinesthetic learners demonstrate the ability to recheck information, strategies, and calculations step by step. However, not all students are able to consistently complete the problem-solving process in an orderly sequence until the final answer is obtained. At the evaluation stage, students do not consistently perform comprehensive reviews of all solution steps, although they are able to detect errors and reflect on alternative strategies. These results differ from the findings of [17], who reported that kinesthetic learners tend to consistently recheck their solution steps.

This discrepancy may be influenced by differences in conceptual understanding, prior learning experiences, and time limitations during task completion.

From the perspective of metacognitive knowledge components, kinesthetic learners have not yet fully mastered problem understanding, but they are able to apply appropriate strategies and solution steps to obtain answers. However, evaluation of the entire solution process is not carried out consistently. In terms of metacognitive experience components, students believe that the strategies used will be successful because they have been learned previously, are aware of alternative strategies, and feel confident in the chosen methods, although some uncertainty remains regarding the accuracy of their calculations. The results indicate that not all indicators of the metacognitive process in solving mathematical problems appear in every student with visual, auditory, read/write, and kinesthetic learning styles. This finding suggests that there are variations in the metacognitive processes exhibited by students with different learning styles (visual, auditory, read/write, and kinesthetic) when solving mathematical problems. The limitation of this study lies in the limited use of a more diverse range of problems that could encompass all indicators of the metacognitive process. In addition, the study did not consider learning processes that take students' learning styles into account, which may have limited the development of students' metacognitive abilities.

4. Conclusion

Based on the results of data analysis, it can be concluded that students' metacognitive processes in mathematical problem solving differ according to their VARK learning styles. Students with a visual learning style demonstrate strong metacognitive knowledge in understanding problems, identifying relevant information, and applying systematic solution strategies, and their metacognitive experience is reflected in the use of prior knowledge and the tendency to review their work when uncertainty arises. Auditory learners are able to understand problems and apply solution strategies but are less optimal in documenting information, monitoring the problem-solving process, and evaluating results; nevertheless, they show confidence in familiar strategies and awareness of alternative methods, although rechecking is limited. Students with a read/write learning style exhibit strong metacognitive knowledge in problem understanding, information recording, and monitoring strategies and calculations, but do not consistently conduct comprehensive evaluations; their metacognitive experience includes checking results during problem solving and recognizing alternative strategies, though not always linked to prior experience. Kinesthetic learners are able to record information and apply strategies to obtain solutions, but their evaluative processes are not yet optimal; their metacognitive experience indicates confidence in previously learned strategies, awareness of alternative methods, and limited checking when uncertainty occurs. Based on these findings, teachers are encouraged to consider students' learning style differences when designing instruction that supports metacognitive development, particularly at the evaluation stage, and future research is recommended to use a wider variety of problems to examine metacognitive processes more comprehensively.

References

[1] N. K. Rahmawati, S. B. Waluya, Rochmad, and I. Hidayah, "Metacognitive skills analysis of students in integral calculus problem solving," *Jurnal Pendidikan Matematika dan IPA*, vol. 12, no. 2, pp. 170–179, 2021, doi: 10.26418/jpmipa.v12i2.45052.

[2] J. A. Livingston, *Metacognition: An Overview*. Buffalo, NY, USA: University at Buffalo, 2003.

[3] Wardawaty, N. Arsyad, and Alimuddin, "Analisis keterampilan metakognitif dalam pemecahan masalah matematika ditinjau dari gaya kognitif," Makassar: Universitas Negeri Makassar, 2018.
[4] J. H. Flavell, "Metacognition and cognitive monitoring: A new area of cognitive-developmental inquiry," *American Psychologist*, vol. 34, no. 10, pp. 906–911, 1979, doi: 10.1037/0003-066X.34.10.906.
[5] Marchis, T. Balogh, and N. Johnson, "Examining self regulated learning in relation to certain selected variables," *Acta Didactica Napocensia*, vol. 5, no. 3, pp. 1–10, 2012.
[6] E. Yurtbakan, T. A. İskenderoğlu, and G. Güneş, "Improving primary school teachers' problem-posing skills by using narrative texts," *Thinking Skills and Creativity*, vol. 59, p. 101956, 2026, doi: 10.1016/j.tsc.2025.101956.
[7] Adinda *et al.*, "Characteristics of prospective mathematics teachers' problem solving in metacognitive awareness," *Journal of Higher Education Theory and Practice*, vol. 23, no. 11, pp. 1–12, 2023, doi: 10.33423/jhetp.v23i11.6220.
[8] S. Mawaddah *et al.*, "Metacognitive misdirection of prospective mathematics teachers in mathematical problem solving," *Participatory Educational Research*, vol. 12, no. 6, pp. 1–15, 2025, doi: 10.17275/per.25.78.12.6.
[9] S. S. Faradiba and A. Alifiani, "Metacognitive blindness in mathematics problem-solving," *Journal of Education and Learning Mathematics Research*, vol. 1, no. 2, pp. 1–10, 2020, doi: 10.37303/jelmar.v1i2.27.
[10] R. Maliana *et al.*, "Expectations versus reality: A case study of metacognitive blindness in mathematics problems," *AIP Conference Proceedings*, vol. 3316, no. 1, pp. 1–8, 2025, doi: 10.1063/5.0290041.
[11] M. Wuryanie *et al.*, "Intuition characteristics of student in mathematical problem solving in cognitive style," *Journal of Education and Learning Mathematics Research*, vol. 1, no. 2, pp. 31–42, 2020, doi: 10.37303/jelmar.v1i2.25.
[12] K. Beltran *et al.*, "Visual, auditory, read/write and kinesthetic (VARK) model-based peer teaching approach," *Educative: Jurnal Ilmiah Pendidikan*, vol. 3, no. 1, pp. 1–10, 2025, doi: 10.70437/educative.v3i1.937.
[13] Fikri and K. Nuradina, "Identification of student learning style preference profiles in hybrid learning settings," *West Science Interdisciplinary Studies*, vol. 1, no. 9, pp. 1–10, 2023, doi: 10.58812/wsis.v1i09.205.
[14] Alghamdi, A. K. Jitendra, and A. E. Lein, "Teaching students with mathematics disabilities to solve multiplication and division word problems," *ZDM Mathematics Education*, vol. 52, no. 1, pp. 125–137, 2020, doi: 10.1007/s11858-019-01078-0.
[15] P. A. Udil, T. A. Kusmayadi, and Riyadi, "Metacognition process of students with high mathematics anxiety," *International Journal of Science and Applied Science*, vol. 2, no. 1, pp. 261–268, 2017, doi: 10.20961/ijsascs.v2i1.16724.
[16] R. A. Cahdriyana, "Kesulitan metakognisi siswa dalam memecahkan masalah matematika," *Jurnal MathEducation Nusantara*, vol. 4, no. 2, pp. 1–10, 2021, doi: 10.54314/jmn.v4i2.154.
[17] F. Sharif *et al.*, "The effectiveness of metacognitive knowledge and skills program," *Health Education and Health Promotion*, vol. 11, no. 4, pp. 549–556, 2023, doi: 10.58209/hehp.11.4.549.
[18] Dinar, Y. Mulyanti, and H. S. Lukman, "Analisis kemampuan metakognisi siswa dalam pemecahan masalah matematika," *De Fermat*, vol. 5, no. 2, pp. 1–10, 2022, doi: 10.36277/defermat.v5i2.180.
[19] F. Nuraini, A. Setiani, and N. A. Nurcahyono, "Analisis kemampuan metakognisi siswa ditinjau dari tipe kepribadian," *Jurnal Cendekia*, vol. 8, no. 1, pp. 1–10, 2024, doi: 10.31004/cendekia.v8i1.2678.

[20] S. Campbell *et al.*, "Purposive sampling: Complex or simple?" *Journal of Research in Nursing*, vol. 25, no. 8, pp. 652–661, 2020, doi: 10.1177/1744987120927206.
[21] D. L. Morgan, "After triangulation, what next?" *Journal of Mixed Methods Research*, vol. 13, no. 1, pp. 6–14, 2019, doi: 10.1177/1558689818780596.
[22] H. Ames, C. Glenton, and S. Lewin, "Purposive sampling in qualitative evidence synthesis," *BMC Medical Research Methodology*, vol. 19, no. 26, pp. 1–9, 2019, doi: 10.1186/s12874-019-0665-4.
[23] E. Trisnawati and N. Riana, "Analisis kemampuan komunikasi matematis siswa," *Hipotenusa Journal of Research Mathematics Education*, vol. 1, no. 2, pp. 1–10, 2022, doi: 10.36269/hjrme.v1i2.785.
[24] J. Crossman and S. Bordia, *Handbook of Qualitative Research Methodologies in Workplace Contexts*. Cheltenham, UK: Edward Elgar, 2021.
[25] Z. N. Ghafar, "The evaluation research: A comparative analysis," *Journal of Language, Literature, Social and Cultural Studies*, vol. 2, no. 1, pp. 1–10, 2024, doi: 10.58881/jllscs.v2i1.122.
[26] R. S. Natow, "The use of triangulation in qualitative studies," *Qualitative Research*, vol. 20, no. 2, pp. 160–173, 2020, doi: 10.1177/1468794119830077.
[27] T. S. Sheromova *et al.*, "Learning styles and development of cognitive skills in mathematics learning," *Eurasia Journal of Mathematics, Science and Technology Education*, vol. 16, no. 11, pp. 1–13, 2020, doi: 10.29333/EJMSTE/8538.