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Analysis of Errors in Solving Numeracy Problems Based on the Newman Procedure, Viewed from the Metacognition Levels of Fifth-Grade Elementary School Students

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Abstract: Student errors in solving numeracy problems often stem not only from cognitive limitations but also from low metacognitive awareness regarding the planning, monitoring, and evaluation of thought processes. This study aimed to describe the metacognition levels of fifth-grade students at State Elementary School Gunung Sunda, as well as the types and stages of errors committed—based on Newman's Procedure—at each metacognition level. A qualitative descriptive approach was employed, involving three subjects selected purposively to represent high, medium, and low metacognition categories, determined through the triangulation of observations, interviews, and test answer sheets. The results indicate that the distribution of student metacognition was dominated by the low category. The student with high metacognition committed only a minor encoding error, with no errors at other stages. The student with medium metacognition exhibited inconsistent patterns: active monitoring but incomplete evaluation on one problem, and cumulative errors across five stages on another problem due to a reading error. The student with low metacognition experienced all five types of Newman's errors, resulting from the simultaneous absence of the three metacognitive components.

Keywords: numeracy problem solving errors, Newman procedure, student metacognition, elementary school

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INTRODUCTION

This template The 21st century places numeracy skills as a fundamental competency integral to everyday life. Numeracy is an individual's ability to use mathematical concepts, procedures, facts, and reasoning to solve problems in a variety of real-life contexts (OECD, 2018). This ability extends beyond mere calculation skills to include critical thinking, analyzing quantitative information, and making rational, data-driven decisions. At the international level, the 2022 PISA results showed that Indonesia obtained a mathematics score of 366 points , 106 points below the OECD average (472 points). ranked 70th out of 81 participating countries (OECD, 2023). This achievement demonstrates that Indonesian students' mathematical literacy skills generally require serious attention, particularly in the areas of reasoning and application of mathematics in real-life contexts.

Unfortunately, the numeracy achievement of elementary school students in Indonesia is still far from adequate. Supriyanto et al. (2024) reported that 76 percent of elementary school students obtained numeracy scores in the medium, low, or very low categories, with an average score across the four AKM content domains reaching only 39.4. A similar picture was also found at Gunung Sunda Public Elementary School, the location of this study. Based on the 2025 Education Report data, the average numeracy ability of students at this school was recorded at 64.23, with the lowest achievement in the Data and Uncertainty domain (58.40) and at the cognitive reasoning level or L3 (56.58). This low numeracy achievement is inseparable from errors that occur in the problem-solving process itself. One approach that is widely used to analyze these errors in mathematics education research is Newman's Error Analysis or Newman Procedure, which identifies errors through five hierarchical stages: reading the problem (reading), understanding the problem (comprehension), transforming the problem into a mathematical model (transformation), carrying out calculation process skills (process skills), and writing the final answer (encoding) (Hartana et al., 2023).

However, students' problem-solving errors cannot be fully understood solely from a cognitive perspective. Other internal factors play a role, namely metacognitive abilities, an individual's awareness and knowledge of their own cognitive processes, and the ability to consciously control and regulate these processes (Husema et al., 2021). Students with strong metacognition tend to plan strategies before working on problems, regularly monitor the accuracy of each step, and evaluate the appropriateness of the final answer to the problem context—three abilities directly related to successfully passing Newman's five stages (Mursyidah et al., 2023). Conversely, weak metacognitive components have the potential to increase the likelihood of various types of errors in solving numeracy problems (Shodikin et al., 2022). There has been considerable research on the Newman Procedure in numeracy problems in elementary schools, as has research on metacognition in mathematics problem solving. Mursyidah et al. (2023) found that reading errors were dominant in low-ability students, while errors in processing skills and answer writing were more common in medium- and high-ability students. Kurniawan and Wijayanti (2022) showed that high-ability students are able to plan, monitor, and evaluate independently, while students with medium and low abilities do less monitoring and evaluation. However, research that specifically integrates the two by using the level of metacognition as a review variable in the analysis of Newman's errors in numeracy problems at the elementary school level is still very limited. This gap is the basis for the urgency of this research. Based on this description, this study aims to describe the level of metacognition of fifth-grade students at Gunung Sunda State Elementary School, as well as the types and stages of errors made by students with high, medium, and low levels of metacognition in solving numeracy problems based on the Newman Procedure. Through this research, it is hoped that a comprehensive picture of the characteristics of student errors per metacognitive level can be obtained, so that the results can serve as an empirical basis for teachers in designing more meaningful numeracy learning and remedial programs.

METHODS

This study uses a qualitative approach with a descriptive research type. This approach was chosen because the study aims to understand in depth the phenomenon of errors made by students in solving numeracy problems and the metacognitive processes that arise during problem solving (Moleong, 2018). The study was conducted at Gunung Sunda Public Elementary School, Jalan Raya Cisolok Km. 5, Cimaja Village, Cikakak District, Sukabumi Regency, West Java Province, for approximately six months from January to June 2026. The research subjects were fifth-grade students who served as the main data source. Based on the results of metacognitive behavior observations conducted simultaneously with the test on April 27, 2026, on 11 students who attended, three students were purposively selected, each representing the high, medium, and low metacognition categories. The three students—given the initials WR, MH, and PF—were the subjects of in-depth interviews on April 28, 2026. The principal and fifth-grade teacher were involved as supporting informants through interviews on May 4, 2026.

The research instruments included: (1) a numeracy test consisting of 10 contextual descriptive questions structured based on the Learning Objectives and Learning Outcomes of the Independent Curriculum and the AKM framework of the Ministry of Education, Culture, Research, and Technology (2022); (2) a metacognitive behavior observation sheet containing nine indicators (P1–P3 planning, M1–M3 monitoring, E1–E3 evaluation) with a scale of 1 to 4 for a maximum score of 36; (3) a semi-structured interview guide with 13 questions corresponding to the metacognition indicator codes; (4) a Newman Procedure error analysis sheet with codes RE, CE, TE, PE, and EE; and (5) a documentation study in the form of test answer sheets, field notes, and interview recordings. All supporting instruments were validated through expert judgment by three validators (two expert lecturers in mathematics education and one experienced elementary school teacher) with an average score above 2.51, thus being declared suitable for use.

Data analysis followed Miles et al.'s (2014) interactive model, which consists of data reduction, data presentation, and conclusion drawing and verification. Data reduction was carried out in the following order: first determining each subject's metacognitive level based on observation and interview triangulation, then identifying and coding Newman's error types per item per subject. Data validity was guaranteed through four trustworthiness criteria commonly used in qualitative research (Miles et al., 2014): credibility through method and source triangulation and member checking, transferability through thick description, dependability through audit trail, and confirmability by ensuring each error code was confirmed from two data sources simultaneously.

Research Subjects

Three subjects were purposively selected based on metacognitive behavior observation scores: WR with a score of 33 representing the high category, MH with a score of 23 representing the medium category, and PF with a score of 17 representing the low category.

RESULTS

Student Metacognition Level

Determination of students' metacognitive levels was conducted through triangulation of three data sources: observation sheets, in-depth interviews, and review of test answer sheets. From observations of 11 students present on April 27, 2026, the distribution of metacognitive levels was obtained as presented in Table 1.

Table 1. Distribution of Metacognition Levels of Fifth Grade Students at Gunung Sunda Elementary School

Category	Score Range	Number of Students
Tall	28–36	2
Currently	19–27	4
Low	9–18	5

Nearly half of the fifth-grade students were in the low metacognitive category. This finding confirms the fifth-grade teacher's description that only a handful of students demonstrated independent thinking when working on problems. WR demonstrated the most consistent metacognitive behaviors: reading the entire problem before working, highlighting key words, asking the teacher when having difficulty, and double-checking answers before handing in the worksheet. MH demonstrated active behavior in the early problems but was inconsistent on the long, table-based problems, with one instance of self-correction that was not completed. PF displayed almost no observable indicators of metacognition and relied directly on peer responses.

Newman's Errors in Students with High Metacognition

Newman's error analysis on WR showed the most minimal profile among the three subjects. Of the 10 problems worked, eight were completed without error at any stage. No reading errors , comprehension errors , transformation errors , or process skill errors were found . Only two encoding errors were found, both in Problem 3 and Problem 10. In Problem 3, WR wrote the subtraction return as 100,000 − 53 = 47,000, where 53 is an abbreviation of 53,000 without explicit units, making the written operation mathematically invalid, even though the final value happened to be numerically correct. In Problem 10, WR successfully calculated the average running time of both groups correctly, but the final written conclusion did not refer to the results of the calculations just performed.

Newman's Errors in Students with Moderate Metacognition

MH correctly answered 8 of the 10 questions, but the remaining two questions showed the opposite error pattern. In Question 3, there were clear erasures and scribbles on the answer sheet , evidence that MH detected the error and took corrective action (process skill error in the first process). However, after the correction was written, MH did not check its accuracy, so the final answer returned was 97,000, when the correct one was 47,000 (encoding error). In Question 10, no monitoring signs were found at all. MH read the total score for Class A as 78 and Class B as 66, when both should have been 76 (reading error), which triggered a cumulative error chain that included a comprehension error , a transformation error , a process skill error , and an encoding error all in one question.

Newman's Errors in Students with Low Metacognition

PF made errors on 7 of the 10 questions, with the following distribution: encoding error on 5 questions, comprehension error and process skill error on 4 questions each, transformation error on 3 questions, and reading error on 2 questions. Not a single Newman stage was absent from PF's profile. Two qualitative findings are important: first, on Question 3, PF's final score happened to be correct even though the process was invalid; second, PF managed to write the correct arithmetic sequence formula on Question 7 independently, demonstrating the presence of untapped capacity. PF admitted in the interview that "a friend helped me and gave me the answer," indicating that the metacognitive cycle never started independently.

Recapitulation of Newman's Errors Based on Metacognition Levels

A recapitulation of Newman's error types in the three subjects is presented in Table 2.

Newman's Stages	WR (High)	MH (Medium)	PF (Low)
Reading Error	–	–	2 questions
Comprehension Error	–	–	4 questions
Transformation Error	–	–	3 questions
Process Skill Error	–	1 question	4 questions
Encoding Error	2 questions	2 questions	5 questions

Encoding errors were the only type of error present at all three levels of metacognition. The other error types showed a clear gradient pattern: reading errors , comprehension errors , transformation errors , and process skill errors were entirely absent in WR, limited in MH, and massive in PF.

DISCUSSION

The results of the study showed that almost half of the fifth-grade students at Gunung Sunda Elementary School (5 people) were in the low metacognition category, while only 2 people were in the high category and 4 people were in the medium category. This pattern can be understood through the metacognition theory framework (Husema et al., 2021) that metacognition is not an innate ability that develops automatically, but rather needs to be cultivated through learning experiences that explicitly provide space for students to plan, monitor, and evaluate their own thinking processes. When mathematics learning is more oriented towards the correctness of the final answer rather than the thinking process, these three regulatory components do not get the opportunity to be trained. This finding is in line with Husema et al. (2021) who found a similar pattern in junior high school students: high-ability subjects met almost all indicators of planning, monitoring, and evaluation, while low-ability subjects did not meet the indicators in all three components.

WR's error profile included only two minor encoding errors out of 10 questions with no errors in other stages, demonstrating how optimally functioning metacognition acts as a multi-layered protection system against errors. Active planning allows for the selection of appropriate strategies early on, preventing transformation errors; consistent monitoring prevents process skill errors; and evaluation detects most inconsistencies. The persistent encoding errors in WR indicate weaknesses in output monitoring (Mursyidah et al., 2023), the ability to check whether written work represents true understanding. This is in line with Mursyidah et al. (2023) who found that encoding errors persist even in high-ability students because numeracy questions require the ability to interpret and communicate results in context.

The MH profile illustrates the distinctive characteristics of moderate metacognition through the contrast of two opposing errors. In Question 3, scribbles and erases provide physical evidence of active monitoring, but the lack of verification after correction results in the encoding error persisting, a condition referred to as monitoring without verification (Husema et al., 2021). In Question 10, the lack of monitoring from the start causes a single reading error to trigger a cumulative error chain across five stages. This pattern confirms that moderate metacognition is not merely a half-assed regulation, but rather a regulation that is present in certain situations and absent in others, consistent with the findings of Riani, Kurniawan, et al. (2022) that moderate-ability students demonstrate all three components of metacognition but inconsistently, particularly in the planning stage.

PF's profile, with errors on 7 out of 10 problems and the presence of all five Newman error types, confirms that the simultaneous absence of all three metacognitive components results in students being unable to initiate, execute, or check the solution process independently. The finding of PF's success in writing the arithmetic sequence formula independently and correctly on Problem 7 confirms the view put forward by Husema et al. (2021) that low metacognition does not mean zero cognitive capacity. Shodikin et al. (2022) explain that long-term dependence on external assistance hinders numeracy development not because cognitive capacity is absent, but because existing abilities are never trained independently.

The most important finding of this study is the dominance of encoding errors across levels of metacognition. the only type of error present in WR, MH, and PF. This is in line with Mursyidah et al. (2023) who stated that context-based numeracy problems require not only calculation accuracy but also the ability to communicate results appropriately according to context, a skill that requires active metacognitive evaluation. In contrast to Mawardi's (2022) study, which identified careless errors and conceptual errors as two main categories without linking them to metacognitive levels, this study shows that the severity of encoding errors increases gradually as students' metacognitive levels decrease, from mild in WR, resulting in erroneous final results in MH, to being present alongside all other error types in PF.

CONCLUSION

This study concluded that the metacognitive level of fifth-grade students at Gunung Sunda Elementary School was predominantly low, and the metacognitive level contributed significantly to the Newman error patterns made by students. Students with high metacognitive skills only made minor encoding errors without errors at other stages because the three components of metacognition, namely planning, monitoring, and evaluation, were not affected. running actively and supporting each other. Students with moderate metacognition show inconsistent patterns, with all three components of metacognition simultaneously, although still leaving cognitive capacity that has not been managed optimally. monitoring all three components of metacognition simultaneously, although still leaving cognitive capacity that has not been managed optimally. active but incomplete evaluation on one question and the absence of all three components of metacognition simultaneously, although still leaving cognitive capacity that has not been managed optimally. monitoring all three components of metacognition simultaneously, although still leaving cognitive capacity that has not been managed optimally. at all on other questions that trigger cumulative errors. Students with low metacognition experience all five types of Newman errors due to the absence of all three components of metacognition simultaneously, although still leaving cognitive capacity that has not been managed optimally.

Encoding errors proved to be the most dominant and persistent error type because they were the only type present at all three levels of metacognition simultaneously, with increasing severity as the level of metacognition decreased. This finding confirms that students' numeracy errors cannot be fully understood solely from the final results, but rather require a process analysis linked to students' metacognitive awareness. The practical implication of this study is the importance of teachers not only assessing the correctness of the final answer but also getting students used to planning, monitoring, and evaluating their thinking processes through consistent scaffolding questions. Future research is recommended to expand the research subject to various schools and develop classroom action research designs to test the effectiveness of metacognition-based learning interventions in reducing Newman errors.

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